Bridge Structure Inspection

Construction Inspector's Training Manual

January 2004

Washington State
Department of Transportation

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Washington State Department of Transportation
Environmental and Engineering Programs
Construction Office

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2:P65:DP/BSI

Introduction

Introduction

This course is intended to introduce you, the inspector, to the components of bridge structures and how they are assembled. You will be able to identify each component and understand its function.

You will also understand the manner of bridge construction and some of the equipment most frequently used to build bridges.

You will learn the formation of elements and their relationship.

Learning will be presented by an experienced instructor using visual aids, charts, illustrations, and thought-provoking questions. The workbook is yours to keep. Hopefully, it will become a valuable reference to you, the inspector.

3:P65:DP/BSI

Definitions

With the advent of Portland cement in the year 1824, industry began to use this product with aggregate and water to produce a stone-like product. It prompted researchers to introduce steel rods to increase strength. This was the beginning of the concrete revolution.

There are many uses for concrete products, such as bridges, roadways, sidewalks, and drainage systems. WSDOT has several hundred projects that incorporate the use of concrete. The department also has many steel and timber structures.

These bridge structures constructed of concrete, steel, or timber are used to provide a vertical span of roadway grades and crossings of waterways or canyons. These features provide safe access to the inaccessible.

Footings

Provide the support for the structure and its dead and live loads. Footing may be spread on piling or drilled shafts.

Columns

These shafts or walls are placed on the foundation and provide the required height for the structure clearances over roadways, rivers, and canyons.

Crossbeams

These beams are placed on the columns and used to support the girders made of concrete, steel, or wood.

Girders

Placed on the crossbeams and will support the roadway and its loads across a designed span between the crossbeams.

Diaphragms

Provide the lateral support between girders.

Roadway Deck

This is the most critical of the entire structure because it will provide the support and ride for vehicles, trucks, buses, and trains. This thin slab of concrete is laced with two layers of reinforcing steel longitudinally and transversely to provide the support for heavy loads.

Traffic Barrier and Bridge Rail

These cast-in-place reinforced concrete barriers provide the safety for errant drivers. The barriers act as guards to prevent vehicles and trucks from going over the side of roadway deck.

Abutments and Wing Walls

Constructed to provide embankment confinement and approach to roadway deck grade.

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Part 1

Introduction

- ***Overview of Course***
- ***Types and Functions of Structures***
- ***Parts of Bridges***
- ***Types of Bridges***

Part 1 Introduction

Bridge Structures Inspection

Course Code ACM

20 hours

Experience

Years with department

Structures experience

- Inspection
- Testing
- Surveying

Concrete has a wide variety of uses in highway construction, including:

- Various types of minor structures.
- Major structures, such as bridges.
- Roadway pavement.

This course concentrates on the inspection of both minor and major concrete structures, but many of the basic concepts and methods are also applicable to concrete pavements.

Overview of Course

Part 2 — Preconstruction Preparation and Staking

- Preconstruction Preparations
- Alignment and Grade Controls

Parts 3, 4, and 5

Basic concrete construction including:

- Prepour Activities, Part 3
- Mix Placement, Part 4
- Post-Pour Activities, Part 5

Parts 6, 7, and 8 — Foundations for Bridges

- Introduction and Dry Excavation, Part 6
- Pilings and Drilled Shafts, Part 7
- Wet Foundations, Part 8

Parts 9, 10, 11, and 12 — Superstructures

- Prefabricated Girders, Part 9
- Cast-in-Place Girders, Part 10
- Bridge Decks, Part 11
- Bridge Deck Widening, Part 12

Types and Functions of Structures

Minor Structures

- Headwalls minimize erosion at ends of pipe culverts.
- Retaining walls hold back material.
- Barrier walls separate traffic.
- Box culverts provide drainage.
- Manholes access to storm and sewer lines.
- Catch basins collect surface water.

Major Structures/Bridges

- To span rivers, streams, etc.
- As overpasses to span other transportation facilities.
- As elevated roadways.
- To span lakes, bays, inlets.

Types of Bridges

Bridges are generally categorized into type of beams or girders used in the superstructure. The more common types of bridges are summarized below and illustrated on the next page.

Prefabricated structural steel bridges:

- Prefabricated steel girders that are erected into position.
- Prefabricated steel diaphragms are usually bolted to the girders.

Prestressed concrete girder bridges, which include:

- Precast (and usually prestressed) concrete beams that are erected.
- Cast-in-place concrete diaphragms are constructed after the girders are set in place.

Concrete box girder bridges which:

- Are cast in place.
- Include a bottom slab, girder walls, diaphragm walls, and a top slab as the deck.
- Sometimes post-tensioned.

Other less-common types of bridges include:

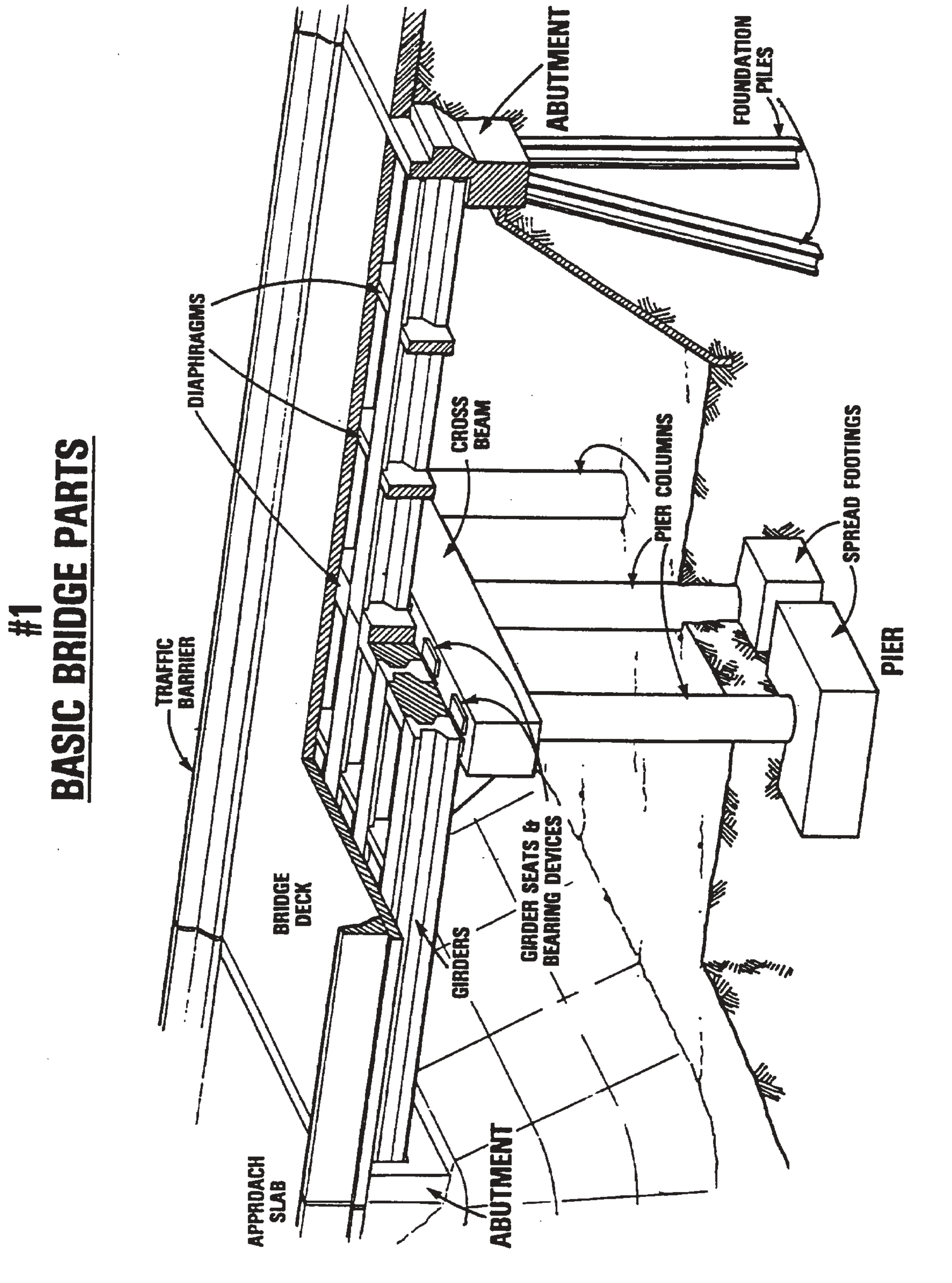
- Concrete box-beam bridges, which are similar in cross-sectional appearance to box girders, but use precast box-beams that are erected into place.
- Continuous concrete slab bridges, which are cast-in-place without any beams or girders.

Basically, the primary differences between bridges and other structures are the larger quantities of materials and the more numerous repetitions of the basic concrete construction operations.

However, certain parts of bridges involve special requirements or construction methods that are relatively unique to bridges and distinguish them from other, smaller concrete structures. They include:

- Special types of foundations, such as pilings or drilled shafts.
- Key considerations for piers and abutments.
- Various methods for different types of beams and girders: circular columns, flared columns, and solid walls.
- Specific requirements for bridge deck construction.

The bulk of this course concentrates on the key aspects of bridge construction in these primary areas.


#1
BASIC BRIDGE PARTS
TRAFFIC BARRIER
DIAPHRAGMS
ABUTMENT
FOUNDATION PILES
CROSS BEAM
PIER COLUMNS
SPREAD FOOTINGS
PIER
BRIDGE DECK
GIRDERS
GIRDER SEATS & BEARING DEVICES
APPROACH SLAB
ABUTMENT

Parts of Bridges

The major parts of the bridge substructures and superstructures are outlined below and illustrated on the next page.

Bridge *substructures* include:

Substructure

The part of the structure below:

1. Simple and continuous span bearings, or
2. The bottom of the girder or bottom slab soffit, or
3. Arch skewbacks and construction joints at the top of vertical abutment members or rigid frame piers.

Substructures include endwalls, wingwalls, barrier and railing attached to the wingwalls, and cantilever barriers and railings.

Superstructure

The part of the structure above:

1. Simple and continuous span bearings, or
2. The bottom of the girder or bottom slab soffit, or
3. Arch skewbacks and construction joints at the top of vertical abutment members or rigid frame piers.

and extending:

1. From the back of pavement seat to the back of pavement seat when the endwalls are attached to the superstructure, or
2. From the expansion joint at the end pier to the expansion joint at the other end pier when the endwalls are not attached to the superstructure.

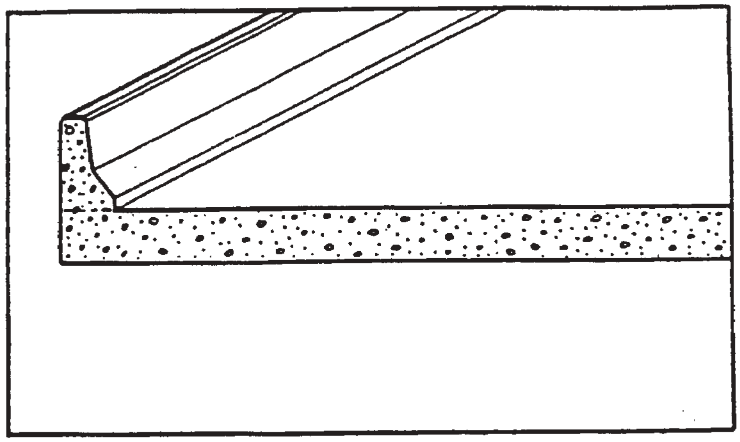
Superstructures include, but are not limited to, girders, slab, barrier, and railing attached to the superstructure.

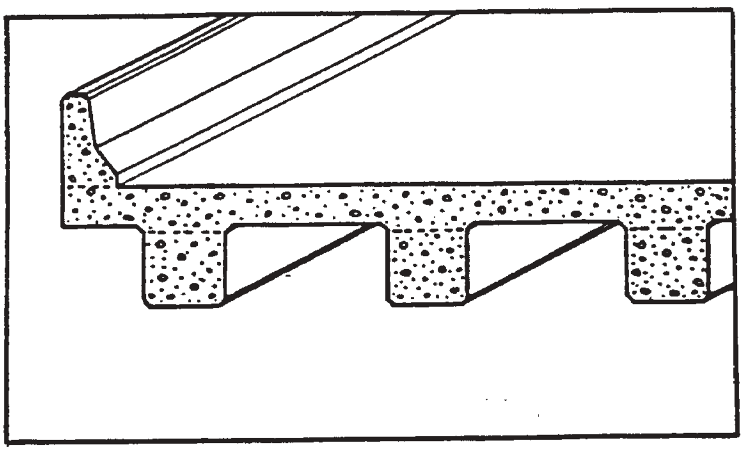
Superstructures **do not** include endwalls, wingwalls, barrier and railing attached to the wingwalls, and cantilever barriers and railings unless supported by the superstructure.

#3

TYPES OF BRIDGES
-- CAST-IN-PLACE CONCRETE --

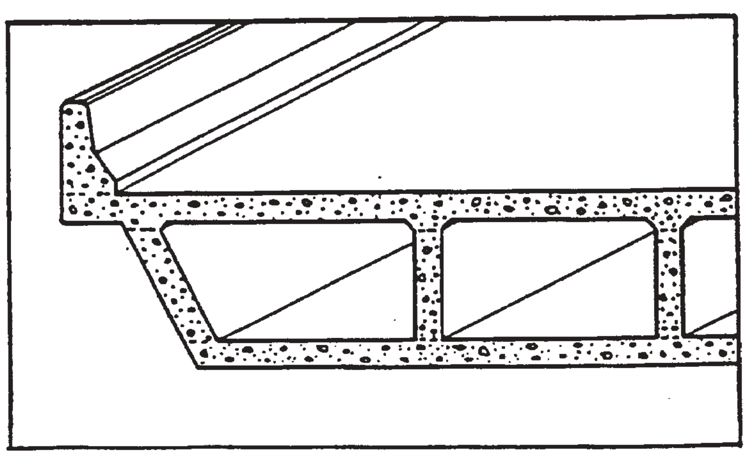
FLAT SLAB

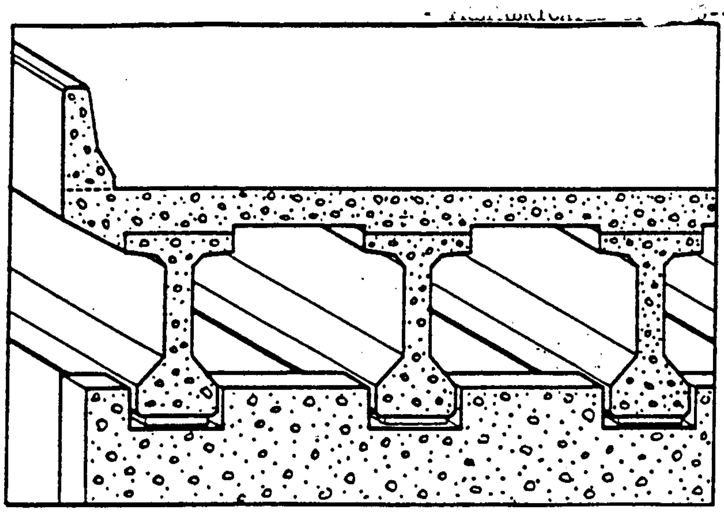




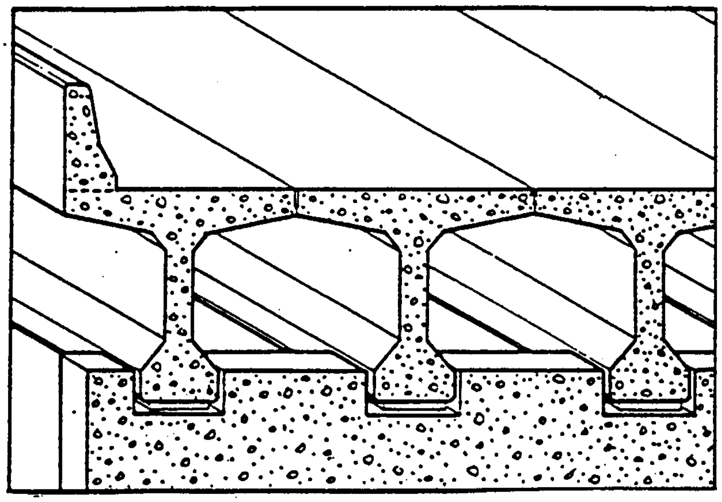
T-BEAM

BOX GIRDER

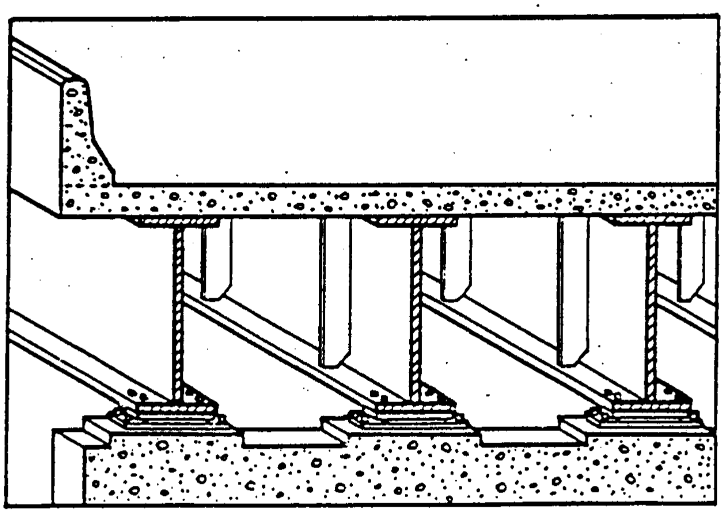




PRESTRESSED CONCRETE I-GIRDERS



PRESTRESSED CONCRETE T-GIRDERS

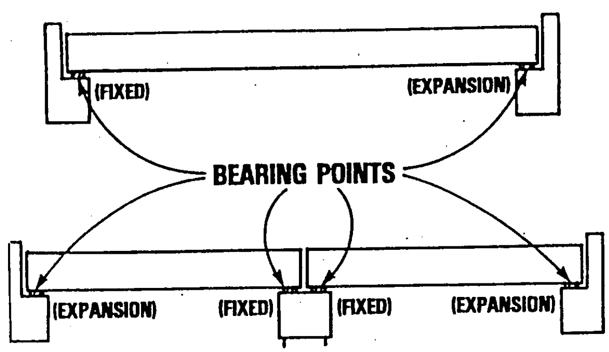


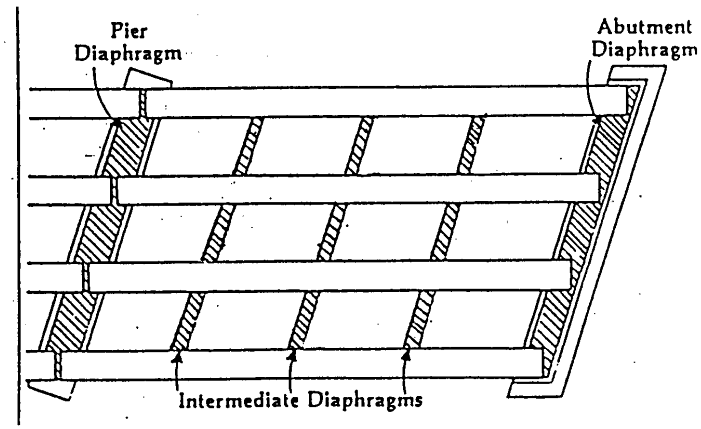
STRUCTURAL STEEL GIRDERS

Types of Bridges

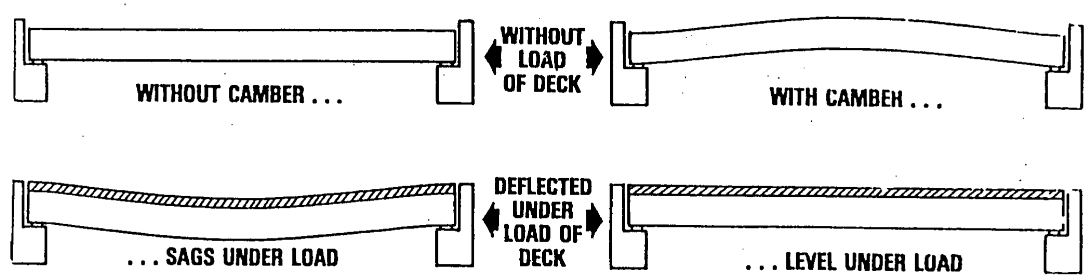
Key Aspects of Bridge Girders

BEARING POINTS





CAMBER AND DEFLECTION



Part 2

Preconstruction Preparations and Staking

- **_Preconstruction Preparations_**
  - *Contract Documents*
  - *Hierarchy of Documents*
  - *Contractor Submittals*
  - *Plans and Familiarization*
  - *Staking for Structures*

- **_Alignment and Grade Controls_**
  - *Footing Columns*
  - *Superstructure — Box Girders*
  - *Contractor Surveying*

Preconstruction Preparations

Contract Documents

All concrete construction operations are governed by the following contract documents:

- *Standard Specifications*. Provide general information and requirements for all projects, but are superseded by other contract documents.
- *Amendments to the Standard Specifications*. Provide revisions, clarifications, and updates to the *Standard Specifications*.
- *Standard Plans*. Drawing and details for frequently used items.
- *Contract Plans*. Provide detailed drawings, tables, charts, etc., for a specific project.
- *Special Provisions*. Provide unique requirements detailed information, clarification, etc., for a specific project and govern overall other contract documents.
- Addendums.

Because of the wide variety in types and designs of concrete structures, the structure inspector should be thoroughly familiar with all the contract documents as they provide the specific materials requirements, dimensions, and other details that distinguish an individual structure from others. The inspector must use the contract documents extensively by:

- Reviewing them thoroughly before the project begins.
- Referring to them frequently throughout all construction operations.

Hierarchy of Documents

1. Addenda
2. Proposal Form
3. Special Provisions
4. Contract Plans
5. Amendments to *Standard Specifications*
6. *Standard Specifications*
7. Standard Plans

Work Drawings

Figured dimensions shall take precedence over scaled dimensions.

Contractor Submittals

Structure project submittals are basically the same as for any project and include:

- Work schedules — bar graph, CPM, etc., as required.
- Equipment for shafts.
- Subcontractor approvals.
- Temporary water pollution/erosion control.

Material approvals are usually more extensive and include information such as:

- Identification of concrete plants and prefabricated plant.
- Mix designs.

Working drawings for approval of methods and details to be used for:

- Shoring, cribs, or cofferdams.
- Forms and falsework.
- Prefabricated items.
- Post-tensioning.
- Fabricated steel items.
- Cold weather plan.

Plans and Familiarization

An inspector’s preconstruction preparations for any project can begin in the office. As soon as possible before the construction begins, you should:

Thoroughly review *all* contract documents, including:

- The plans and special provisions for the project.
- The appropriate *Standard Specifications*, supplemental specifications, and standard drawings that will apply.
- Any contractor-provided documents, such as traffic control plans, falsework and forms designs, and shop drawings for prefabricated items.

Check and verify *all*:

- Comments, approved as noted.
- Plan dimensions.
- Elevations.
- Materials quantities.

List any discrepancies that are discovered and report them to your supervisor (along with any items that may require clarification).

Set up part of your inspection documentation records in advance so that the actual dates, dimensions, quantities, and other values can be more easily filled in as the work progresses.

When inspectors cannot participate directly in the preconstruction conference, you should check with the Project Engineer after the conference to identify any areas of special concern.

Staking for Structures — Construction Manual 1-5.2

The layout of the structures and the references should be independently checked by either a different crew or by the same crew using a different survey approach. All survey notes should also be independently checked. Dimensions on bridge plans are for a normal temperature of 64°F. It is particularly important to keep this in mind when laying out steel structures.

Responsibilities:

- The department is responsible for the basic staking of alignment and grade controls.
- The contractor is responsible for preserving stakes and monuments; accurately using these controls; and setting own stringlines, batterboards, etc.

Alignment and Grade Controls

Footing/Columns

Centerline straddle reference hubs for footing.

Set footing cut stakes for structure excavation to limits shown on the plans. Reference the cut stakes clear of the excavation limits.

Set blue tops (to trim and grade foundation). Use closed level circuit and record.

Stake all pile locations. Designate batter pile, if any. Set elevations for pile cutoffs.

Place straddle tacks on footing forms.

After pour, place straddle tack on footing from primary reference points to use for aligning column.

Set and check elevation for column pour height. Make allowances for superelevation and grade.

Establish location and Plumbness of column forms.

Superstructure — Box Girders

For falsework construction:

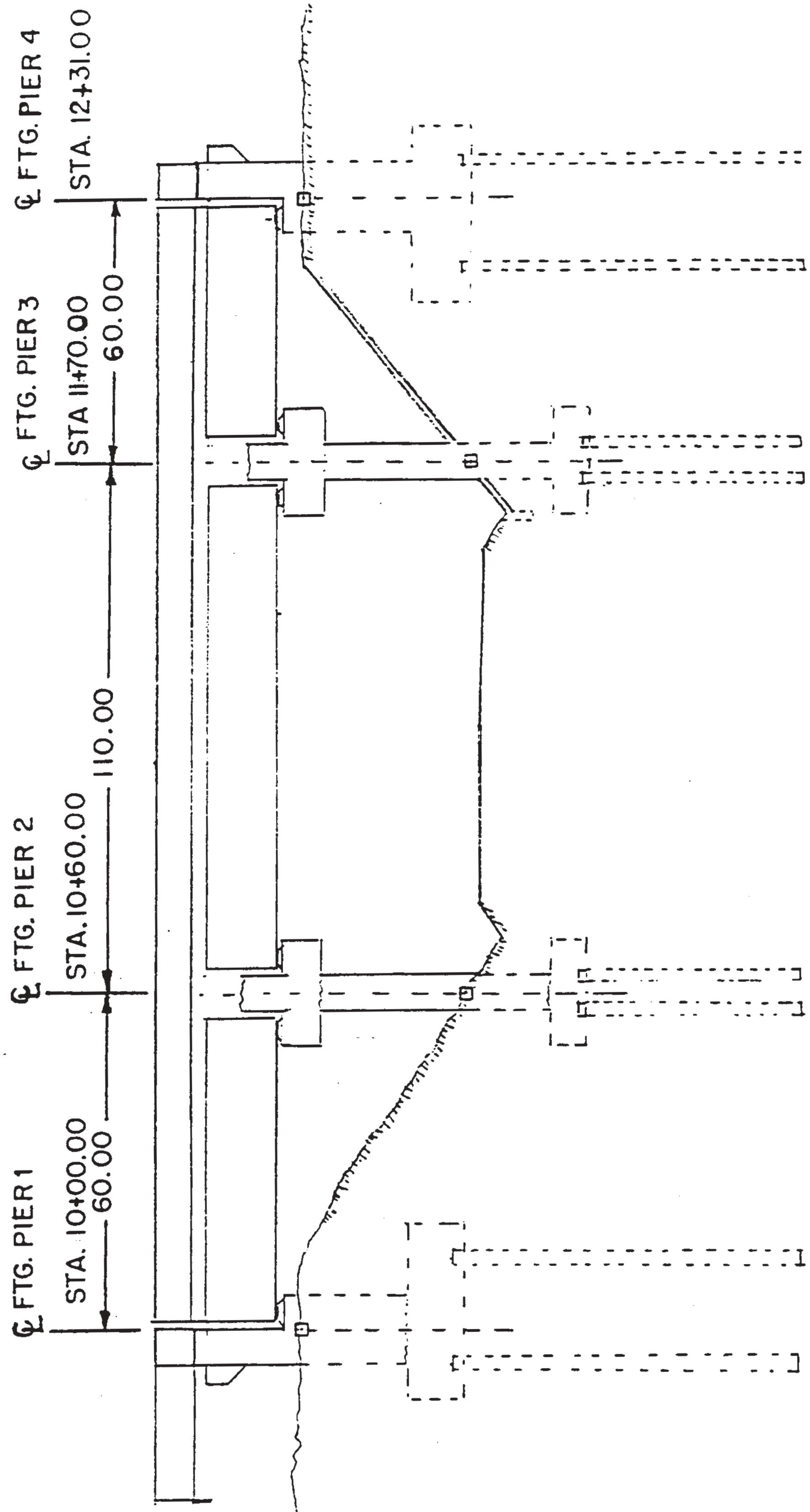
- Set and check one benchmark per span for contractor’s use.
- The contractor may use columns or piers for falsework alignment or WSDOT will set centerline stakes.
- The contractor is expected to set own grades for falsework pads and falsework pile cutoffs.

Set one benchmark for each pier on top of column concrete or steel.

Set grades for the bottom slab on risers attached near the ends of falsework bents and at transverse grade breaks.

- Contractor sets bottom deck forms to grade.

BASIC BRIDGE STRUCTURE LAYOUT



- WSDOT then checks form elevations at point of intersection previously established or at more frequent intervals depending upon grade, curvature, and superelevation.

Set tacks on bottom slab form to:

- Establish intersection of all interior webs and diaphragms.
- For outside edge of box, additional tacks are required when structure is on a curve or flare.
- Contractor sets pour heights, state checks.

All elevations set for bottom deck, girder tops, overhang, and top deck should include camber. Install telltales at the $^1/_4$ points and center of each span (minimum) to verify falsework take-up with each pour.

Set elevations for the top deck forms at about 15 foot centers maximum.

Contractor sets screed rails from elevations furnished and the WSDOT checks. Set finishing machine drum to grade using grades set for top of deck forms. Check adjustments by moving machine over entire deck.

All deck bulkheads, expansion dams, access holes, and drainage castings should be set to final grade from the drum of the finishing machine.

To set traffic barrier grades profile deck at toe of barrier and plot on a large scale to form a smooth line.

Contractor sets anchor bolts for bridge rails, sign supports, and light standards and the WSDOT checks.

The WSDOT establishes location and elevation for all anchor bolts and bearing assemblies.

Contractor Surveying — Construction Manual 1-5.2B and GSP(s)

When contractor surveying is included in a project special provision WSDOT spot-check's the Contractor's surveying.

WSDOT will spot-check the lines and elevations to ensure their accuracy and that they are within the tolerances shown in the plans and special provisions.

WSDOT will continue spot-checking throughout the Contract. A lump sum breakdown is required for payment and survey notes shall be provided to the contracting agency within three days of staking.

The contracting agency will descibe two control points for horizontal and vertical alignment these points shall reference the project alignment and the coordinate system as will as project elevation.

In addition, the contracting agency, shall provide horizontal coordinates for the begining and ending of each Point of Intersect (PI) horizontal coordinates for the centerline of each pier.

Computed elevation at the top of bridge roadwaydecks at one-tenth points at the center of each web. The Contractor shall give there weeks notification for this information.

The Contactor shall provide coordinates for piles, shafts, footings, and columns for verification prior to staking.

The agency requires up to seven calender days to verify submittals for staking, no staking until they have been verified. For traffic barrier, locate the low spot in the bridge profile, from shots taken on the deck at the face of the barrier, prior to placement. From that low spot, set the face of barrier curb at a maximum of three inches. This ensures that the curb height will remain 3 inches or less.

Contractor is responsible for setting anchor bolts in signals, signs, and light standards.

6:P65:DP/BSI

Part 3

Basic Concrete Prepour Activities

- **_Minor Structures_**
  - *Dimensions and Quantities*
  - *Reinforcing Steel*
  - *Reinforcement*

- **_Forms and Falsework_**
  - *Approvals*
  - *Inspection — Formwork*
  - *Wood Forms*
  - *Falsework*

Part 3 *Basic Concrete Prepour Activities*

Minor Structures

Many of our current projects include one or more minor structures (retaining walls, box culverts, headwalls, etc.).

These minor structures are not normally detailed in the plans but must be designed from the standard plans.

The contractor develops the construction drawings, but the inspector needs something to check by.

Dimensions and Quantities

The first item to check is dimensions and quantities. This is best accomplished by drawing a pay note in final record form.

For a type 1 retaining wall 20 feet long and 8 feet high, the note could look like this.

Washington State Department of Transportation

Field Note Record (Sketch Grid)

Book No. ________ Page No. ________

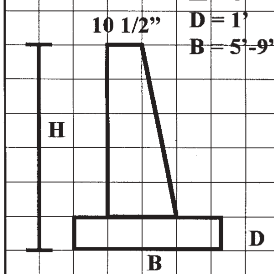
Contract No.	Station	Line	C/S
2000	20+00 to 2100	LE Line	051800

Staked By	Date	Work Started	Work Completed
Contractor Survey	May 15, 2000	May 18, 2000	

Calculated By	Date	Checked By	Date	Inspector's Signature	Date
John Doe	5-16-2000				

H = 8'
D = 1'
B = 5'-9"

Length = 20 feet



Conc. Quantity =
(5.75 x 1 x 20) + (0.875 x 7 x 20) + (0.7 x 7 x 20 x 0.5) = 286.5 / 27 = 10.61c.y.

Check Quantity = 20 x 0.53 = 10.6 c.y.

Bar	Spacing	Size	lb/ft	Length	Quantity	Weight
E	1'-6"	4	0.668	3'-4"	14	31.17
F	9"	4	0.668	3'-3"	27	58.62
K	9"	5	1.043	10'-8"	27	300.38
G	1'-6"	4	0.668	6'-10"	14	63.91
L	1'-4"	4	0.668	19'-9"	12	158.32
Q	-------	4	0.668	19'-9"	7	92.35

Total Weight 704.75

Check = 20' x 35 lb/Lf = 700 lb.

Item No.	Item	Group No.	Date	Unit	Quantity	RAMS No.	Basis of Material Acceptance	CAPS Entry No.	Initials Post	Initials OK	Est. No.
45	Steel Rein. For Ret. Wall	2		lb.							
47	Conc. Cl 4000 For Ret. Wall	2		c.y.							

DOT Form 422-636 EF
Revised 9/96

The drawing could have all the pertinent dimensions, and with these dimensions you can calculate the quantity of concrete required. As a check of the dimensions and calculations, you can use the value given in the *Standard Plans* under Conc. c.y./ft. Multiplying this by the plan length should equal your calculated quantity.

Reinforcing Steel

The next step is to detail the reinforcing steel. The purpose of the re-steel in concrete is to provide tensile strength, so it is important that it is installed in the proper location as defined in the contract plans.

The contractor is responsible for determining and ordering the quantities from the contract plans. For the inspector preparing the pay note for the resteel payment ahead of time is a very effective way to become familiar with the structure and resteel placement.

First draw the end view of the wall on a sheet of paper and sketch in the six bars. Using colored pencils helps to keep from being confused. Then making a listing, including the designation, spacing, size, length, and total quantity and weight of each bar.

Section 6-02.4 gives the diameter and unit mass per meter of reinforcing steel.

Practice Exercise

Using the above format and the standard plans:

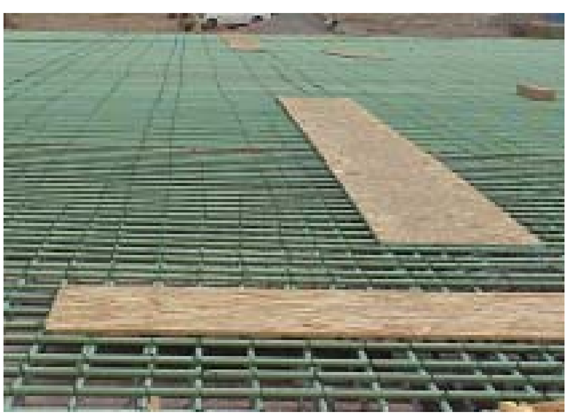
- Draw, dimension, and calculate the concrete quantities.
- Detail a steel bar list including weights for E, K, and L bars only.

For a type 1 retaining wall, 12 feet high and 23 feet long. Worksheet in Appendix C.

Reinforcement

For most structures, some type of reinforcement is required to help improve the overall strength of the structure. For this reason it is important that the correct size, grade and placement location is verified in the field. Reinforcing materials include:

- Uncoated steel bars, which are most commonly used.
- Other types, such as welded ware mesh, epoxy-coated bars, wire, pre-stressing strand.
- Wire ties and other devices to securely hold the reinforcement in place.



Pictured here is the top mat of resteel for the deck Typically the top mat will be epoxy coated resteel. It is required that the tie wire for epoxy coated resteel must be plastic coated.

Delivery

As reinforcing steel is delivered and stored at the project site:

- Check its documentation for proper certification (Figure 3-1).
- Check its source, type, size, bends and grade. *Standard Specification* 9-07 gives reinforcement requirements.
- Check that resteel is stored in area that prevents damage and contamination of bars (Figure 3-2).

Figure 3-1

Reinforcing steel when delivered will be tagged. The tag will give you the mark number, size, manufacturer, bend type and dimensions.

Epoxy reinforcement steel will have an approved for shipment tag attached.

Chapter 9 of the *Construction Manual* gives the required documentation.

Figure 3-2

All resteel must be protected from damage and contamination that can not be cleaned off. This is not the appropriate method of storage for epoxy coated resteel. All resteel should be stored off the ground.

Placement

- Watch for any loose scale or rust and foreign material that could harm the bond with the concrete.
- Verify position, spacing, clearances, lengths and splice locations for conformance to plans.
- Field bending is done in accordance with approved procedure.
- After field bending check resteel for cracking or splitting. If damage has occurred resteel needs to be replaced or repaired.
- See that steel is held firmly in place (*Standard Specification* 6-02.3(24)C).
    - Tie all intersections if spacing between bars is one foot or greater.
    - Tie alternate intersections if spacing between bars is less than one foot
- **No** tack welding is allowed.
    - Welding of resteel is only allowed where shown in the contract plans. **When welding is required** than a welding procedure is required to be submitted and approved.
- Verify that splices are located only where shown in the plans (*Standard Specification* 6-02.3(24)D). Some typical type of splices:
    - Lap Splice (Figure 3-3)
    - Welded Splice
    - Mechanical Splice (Figure 3-3A)

Figure 3-3

Splicing of resteel is for the transferring of loads from bar to bar. Pictured here is a lap splice notice that the bars are tightly against each other as required.

Figure 3-3A

Mechanical splice of vertical bars for retaining wall. Mechanical splices can only be used in areas that splices are allowed and are approved.

- Verify that all reinforcement is securely supported and held in place (see Figure 3-4A) by pre-approved metal chairs, plastic chairs or mortar blocks that meet or exceed the strength of the surrounding concrete (*Standard Specification* 6-02.3(24)C).
- Any metal chair support that will not have more than 1/2 inch of cover shall be either:
  - Hot dip galvanized
  - Coated with plastic bonded to the metal
  - Stainless steel

Figure 3-4A

If spacing of resteel supports is too far apart, sagging or movement of resteel can occur. Spacing for supports is given in the *Standard Specification* 6-02.3(24)C.

Measurement and Payment (*Standard Specification* 6-02.4 and 6-02.5)

Measurement

Computed weight of all steel actual placed and required by the plans.

Payment

Paid per pound.

Forms and Falsework (*Standard Specification* 6-02.3(16) and 6-02.3(17))

Approvals

The contractor is responsible for designing and constructing the forms and falsework for fixed-form concrete work, but they must meet certain requirements.

- Plan approval is not required for footings or retaining walls unless they are more than 4 feet high.
- For footing and retaining walls between 4 and 8 feet Project Engineer may do approval with certain provisions.
- The contractor must submit detailed plans along with calculations (Figure 3-5):
  - Six copies to Construction Support and two copies to the Project Engineers Office (*Standard Specification* 6-02.3(16)A).
  - Additional copies required for U.S. Bureau of Reclamation and/or Railroad.

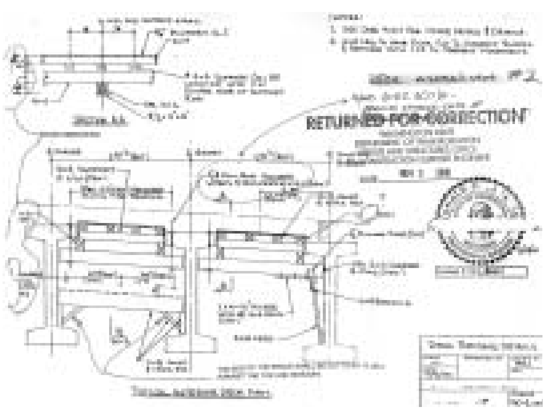


Figure 3-5

Working drawing from contractor with notes from Construction Support. Inspectors job is to make sure that the contractor makes required corrections and constructs forms and falsework per plan.

Inspection — Formwork

All forms must:

- Provide smooth and uniform face.
- Be clean of dirt, laitance, oil and any other material that may contaminate or discolor the concrete.
- Treated with form release agent prior to placement.
- Be mortar tight to avoid leakage.
- Be adequately supported and rigid to prevent distortion or displacement (see Figure 3-6).
- Constructed per the approved drawings.
- All corners must be beveled $^3/_4$ inch.
    - Except for footings, pedestals, seals and traffic barrier.
- Formwork accessories (*Standard Specification* 6-02.3(17)H).
    - Form ties, Form Anchors, Anchoring inserts.
        - Shall permit all metal to have at least $^1/_2$ inch concrete cover when removed.

Wood Forms

- Joints and wood grain generally in line with line of structure.
- No offsets or projections that would leave impression in the concrete surface.
- New plywood used if a Class 1 finish is required.
- Form joints on exposed surfaces shall be in horizontal and vertical plane.
- $^3/_4$ inch plywood required for exposed surfaces of:
    - Abutments
    - Wingwalls
    - Piers
    - Retaining Walls
    - Columns

Verify that formwork is constructed per approved working drawings. Check spacing and dimensions of formwork material. Verify dimensions of formwork to make sure it meets size and shape of structural member to be cast.

Form blowout due to inadequate lateral support.

Figure 3-6

Falsework

Falsework is a temporary structure erected to support work in the process of construction. Falsework is composed of vertical posting (Figure 3-7) to provide the proper elevation and lateral bracing to prevent movement laterally during construction. As with formwork, the contractor must submit falsework drawings along with calculations for approval.

With falsework see that:

- The falsework is on a solid foundation.

  Mudsills

  - Placed on soil that is either undisturbed or compacted to 95%.
  - Mudsill must have full ground contact.
  - Contractor to provide erosion control.

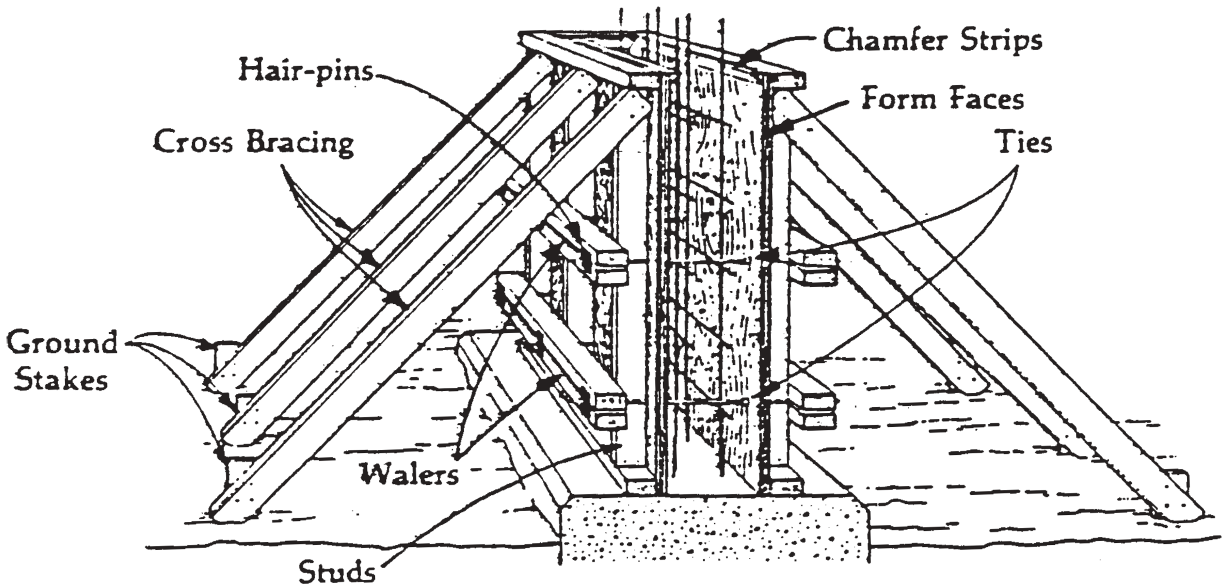
  Wedges

  - To be used in pairs.
  - May be used at top or bottom but not at both locations.
  - Wedges to be secured after final adjust for elevation.

- Falsework is constructed per approved drawings.

Figure 3-7

Vertical members with cross bracing used as falsework to support the construction of a pier cap for a bridge widening.


Chamfer Strips
Hair-pins
Form Faces
Cross Bracing
Ties
Ground Stakes
Walers
Studs

Part 4

Basic Concrete Placement

- ***Fixed-Form Concrete***
  - *Weather and Temperature Limits*
  - *Preparations for Concrete*
  - *Delivery of the Mix*
  - *Mix Placement and Consolidation*
  - *Concrete Joints*
- ***Slip-Form Concrete***
- ***Precast Concrete***

Part 4 Basic Concrete Placement

This section summarizes the key points in inspecting concrete placement operations for fixed-form, slip-form, and precast concrete. Emphasis is placed on the fixed-form method, followed by highlighting the key similarities and differences for the other two methods.

Fixed-Form Concrete

The fixed-form, cast-in-place method can be used for just about any incidental concrete structure. Its basic requirements for weather, preplacement, discharge, consolidation, and finishing are also fundamental to other methods with only certain variations.

Weather and Temperature Limits — Construction Manual 6-2.3A(1)

The two basic weather and temperature requirements for placing concrete are:

- Concrete may not be placed when rain is hard enough to:
  - Cause a muddy foundation.
  - Wash or flow the concrete.
- The temperature of the concrete must be within 55° and 90°F during placement.
- Air temperature at least 35°F during and for seven days after placement (unless approved cold weather plan).

Hot Weather Placement (Air Temperature Above 90°F)

- Cool component materials of mix, transport, and placement equipment, and contact surfaces at site.
- Methods preapproved by Engineer.

Cold Weather Placement

- No concrete is placed against any frozen or ice-coated foundation, forms, or reinforcement.
- A preapproved plan for cold weather placement and curing is required.
- Heat aggregate and/or water to maintain mix temperatures above 55°F.
- Control temperature and humidity after placement by:

  Enclosing concrete.

  Heating to 50 to 90°F for seven days or the cure period stated in section 6-02.3 (11) whichever is longer.
- Add moisture for six days (discontinue 24 hours before heat is stopped).
- An accurate recording thermometer is required.
- Corners and edges require special attention to prevent freezing.

Preparations for Concrete

Even before the contractor orders any concrete for delivery and placement at the site, you should:

- *Thoroughly* inspect the foundation, forms, and reinforcement for the proper dimensions, layout, grade, support, and other requirements.
- Make sure the contractor has adequate resources for the pour:

  A steady supply of mix.

  Adequate labor and equipment.

  Backup equipment at the job site.

Delivery of the Mix — Standard Specification 6-02.3

Collect delivery ticket or certificate of compliance and check:

- Concrete class, per plans.
- The batch of concrete shall be discharged at the project site no more than $1^1/_2$ hours after the cement is added to the concrete mixture. The time to discharge may be extended to 2 hours, if the temperature of the concrete being placed is less than 75°F, with the approval of the Engineer. When conditions are such that the concrete may experience an accelerated initial set, the Engineer may require a shorter time to discharge.
- For transit-mixed or shrink-mixed concrete, the mixing time in the transit mixer shall be a minimum of 70 revolutions at the mixing speed designated by the manufacturer of the mixer. Following mixing, the concrete in the transit mixer may be agitated at the manufacturer's designated agitation speed. A maximum of 320 revolutions (total of mixing and agitation) will be permitted prior to discharge. 30 additional revolutions are required, when remixing, to add water, air entrainment or any additives.

Sample, test, and check temperature at the specified frequency.

Wet down forms and foundation just before placement but no standing water.

Mix Placement and Consolidation

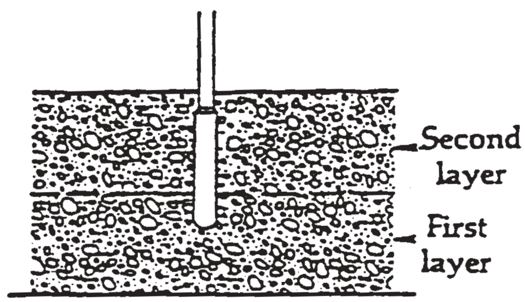
Mix Placement

- Place concrete as close as possible to final position.
- Use appropriate chutes, drop buckets, pumps, conduits, etc.
- Do not drop concrete more than 5 feet.
- Place concrete in layers of 1.5 to 2.5 feet deep.
- The Contractor shall place concrete in the forms as soon as possible after mixing. The concrete shall always be plastic and workable. For this reason, the Engineer may reduce the time to discharge even further. Concrete placement shall be continuous, with no interruption longer than 30 minutes between adjoining layers unless the Engineer approves a longer time.

Proper Vibrator Operation — *Standard Specification* 6-02.3(9)

Concrete must be consolidated to remove entrapped air voids that can occur in corners, along form faces, around reinforcement, or elsewhere in the mix. To see that the concrete is properly consolidated, make sure that:

- Only approved vibrators with a minimum frequency of 7,000 cycles per minute are used.
- Vibrators are operated properly by:
  - ✓ Lowering it into the concrete through the full depth of each layer.
  - ✓ Penetrating into the previous layer on multilayer pours (as shown below).
  - ✓ Avoiding direct contact with form faces and reinforcement.
  - ✓ Holding the vibrator in one place only until the concrete stops settling (to avoid over-vibrating which segregates the larger aggregates to the bottom).

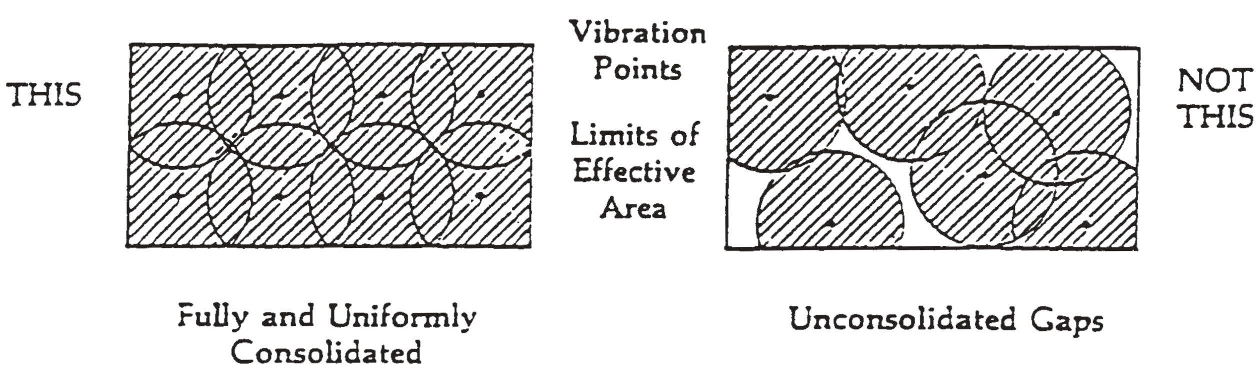


  - ✓ Removing the vibrator slowly and without dragging it across the surface.
  - ✓ Repeating the process with uniform spacing between vibration points so that the effective areas the vibration points overlap for full coverage (as shown on the left of the illustration) — not with wide spacing that leaves gaps of unconsolidated areas (as shown at right).

Consolidation is completed within 15 minutes after the concrete has been placed.

Concrete Joints

The two basic types of concrete joints: (1) construction joints and (2) expansion joints.



Construction Joints — *Standard Specification* 6-02.3(12)

Construction joints are placed between separate pours within the structure. When inspecting construction joints, see that:

- They are constructed *only* at the locations shown in the plans.
- The previous pour is completed:
  - At the correct grade.
  - With properly formed keyways when a keyed joint is required.
  - With extension of the reinforcement or tie bars into the next pour.

Preparations are made for the next pour by:

- Drawing the forms tight.
- Removing any temporary keys.

Cleaning the existing surface, reinforcement, and forms free of any laitance or other foreign material, by:

- Air or water jets, bush hammer, or abrasive blasting.

Saturating the surface with water; and

Don’t forget containment of blasting material or water.

Expansion Joints — *Standard Specification* 6-02.3(13)

Expansion joints use compressible material to allow concrete to expand without breaking.

Expansion joints are typically located:

- Between adjacent concrete structures.
- At specified intervals within linear structures, such as curb and gutter, sidewalk, barrier walls, and ditch pavement.
- Other locations, such as between the headwall and wingwalls of a concrete headwall.

Insure expansion joints are constructed, so that:

- They conform with the plans in terms of the locations, dimensions, and type of joint material used.
- Joint material is placed to the full depth and length of the joint.
- Joint edges are cleaned and edge-finished in accordance with the plans.
- The joints are installed with an approved lubricant adhesive and to the correct depth required by the plans.

Slip-Form Concrete

Such incidental structures as curb, gutter, sidewalks, and barrier walls may be constructed by slip-form, cast-in-place methods.

Preparations for slip-form placement are generally similar to those for fixed-form placement, but:

- No forms are set in advance.
- Special consideration should be given to:
  - Lateral bracing of the reinforcing cage.
  - Making sure that the slip-form equipment has automatic alignment and grade controls.
  - Checking the contractor’s stringline or wire reference closely.

The weather and temperature limits for slip-form work are the same as for fixed-form operations.

The key points in inspecting the placement, consolidation, and finishing the concrete in slip-form operations are:

- Closely monitoring the slump of the mix.
- Controlling the rates of:
  - The feed of concrete into the slip-form equipment.
  - Travel of the equipment.
- Watching for honeycombing, excessive grout, or other indications of inadequate or excessive consolidation.
- Watching for other deficiencies such as pulling, tearing, or excessive edge slump.
- Generally seeing that the results equal or exceed those of fixed-form placement.

Precast Concrete

Catch basins, barrier walls, and retaining walls may be constructed in precast units or sections. Staking and foundation preparations are similar to those for cast-in-place concrete, but the processes of forming, reinforcing, placing, and consolidating concrete, finishing, and curing are usually carried out at the fabrication plant rather than the construction site.

As precast concrete items are delivered to the construction site:

- Make sure that the precast item is stamped to indicate that it has been approved for shipment.
- See that they are transported and stored properly:
  - In an upright position.
  - With support at the final bearing points.

- Inspect them closely for such defects as:
  - Deviations from plan dimensions.
  - Exposed reinforcement.
  - Honeycombing.
  - Cracks.

Before precast units are set in place, special consideration must be given to their foundations, including:

- A special backfill bedding — for catch basins or similar precast items — that must be:
  - At least 6 inches deep.
  - Compacted to at least 95 percent of the maximum lab density of the material.
  - At or near optimum moisture at the time the precast unit is placed.
  - Shaped to fit the bottom of the precast unit.
  - Trimmed or filled in as needed to provide full uniform support of the structure.
- A cast-in-place concrete footing — as commonly used for retaining walls — including any shims or bearing pads that may be required.

Other key points to watch for in the installation of precast concrete units are:

- Proper handling by means of special lifting holes, loops, or devices to minimize uneven stress that could damage the item.
- Correct alignment and grade of the precast unit as it is set in place.
- Provided with adequate temporary support, as needed (particularly for precast retaining wall panels) until other construction operations can be completed.
- Properly constructed joints between precast sections, including:
  - Mortared construction joints between catch basin sections.
  - Doweled, sealed, and pressure-grouted joints between barrier-wall sections.
- Removal and finishing of lifting devices, including:
  - Filling and finishing lifting holes with mortar.
  - Removing lifting loops below the surface, filling the recesses with mortar, and finishing the surface.

8:P65:DP/BSI

Part 5

Basic Concrete Post-Placement Activities

- **Finishing Unformed Surfaces**
  - *Curing Methods*
  - *Curing for Traffic and Pedestrian Barrier*

- **Removing Forms and Falsework**

- **Finishing Formed Surfaces**
  - *Class 1*
  - *Class 2*

- **Backfilling**

Part 5 *Basic Concrete Post-Placement Activities*

Finishing Unformed Surfaces

The unformed top surface of a structure must be finished after placement and consolidation are completed. As the unformed surface is finished, see that:

- The surface is struck off to correct grade.

  For narrow tops of walls, chamfer strips or grade nails are adequate.

  For flat, horizontal slabs, some type of strike board is usually needed.

- Basic finishing:

  Wood floats are used for initial finishing.

  Metal floats and trowels are used to smooth and seal the surface.

- Special finishing treatments:

  All finishing requirements must be completed such as:

  ✓ Final fine brush finish on barrier walls.

  ✓ Exposed-aggregate finish (as often specified for slope pavement).

  Curing is started immediately after the unformed surface has been finished.

Curing

The hardening of concrete must be properly cured to control cracking, shrinkage, and warping. See that all concrete is cured:

- For the specified period of time (minimum time required):

  Bridge roadway slabs (except when Class 4000D is used) — **10 days.**

  Bridge roadway slabs using Class 4000D — **14 days.**

  Retaining walls, culvert sidewalls, and culvert floors — **10 days**.

  All other concrete surfaces (except traffic barriers and rail bases) — **3 days**.

- By using the proper method:

  Bridge roadway slabs (except when using Class 4000D):

  - Curing compound covered by white reflective sheeting for required time.

    or

  - Continuous wet curing for required time.

  Bridge roadway slabs using Class 4000D:

  - Continuous wet cure with heavy quilted blankets or burlap for required time, and two coats of curing compound.

Retaining walls, culvert sidewalls, and culvert floors:

- Continuous moisture for minimum required time.

All other concrete surfaces:

- Continuous moisture for minimum required time.

Curing Methods

White Curing compound:

- Applied after bleed water has evaporated.
- Applied in two coats, second coat at right angle to first coat.
- Applied at a minimum rate of 1 gallon per 150 square feet.
- Contractor shall supply backup spray equipment.
- No later than the next day, white reflective sheeting to be placed (Figure 5-3).

Figure 5-3

White plastic sheeting covers previous deck pour. The sheeting helps maintain moisture with in the concrete.

Wet Cure (Figure 5-4):

- By watering a covering of heavy quilted blankets or burlap.

or

- Watering, then covering with white reflective sheeting.
- Blankets or burlap to remain moist for required curing time.
- Runoff water will **not** be allowed to enter any surface waters.

Figure 5-4

Burlap blankets after required cure time with plastic cover removed. Soaker hose used to maintain moisture.

Curing for Traffic and Pedestrian Barrier

Fixed form barrier:

- Cover top surface with heavy quilted blankets.
- Spray water on forms and blankets to keep them wet for three days.
- After form removal, keep blankets continuously wet for seven days.

Note: Contractor may start finish work during second cure period as long as blankets are left on barrier except in the immediate work area.

Slip form barrier:

Method A:

- Spray two coats of clear curing compound rate of 1 gal/150 ft^2.
- No later than next morning, cover with white reflective sheeting for ten days.

Method B:

- First 24 hours — mist or fog spray.
- After first 24 hours, cover with quilted blankets.
- Keep blankets continuously wet for at least ten days.

Removing Forms and Falsework

The basic requirements for the removal of any forms and falsework are that:

- No forms or falsework may be removed until authorized by the Engineer.
- All forms or falsework must eventually be removed unless there is no permanent access, e.g., box girder bridge.
- All forms and falsework must be removed in a manner that will not damage the structure.

Timing is a key consideration in the removal of forms and falsework. In terms of curing the concrete, forms and falsework must remain until the concrete is sufficiently set or hardened to support itself. But for finishing purposes, it is generally better to remove the forms as early as possible to finish the surface while it is still green. So the timing of falsework and forms removal depends largely on the type of structure as well as its curing and finishing. For example:

- Side forms — not load bearing:

  At least 24 hours for:

  ✓ Footings, if curing compound applied to complete cure.

  ✓ Steel or dense plywood if: (1) water reducer in mix, (2) low-slump mix, (3) 1400 psi compressive strength, and (4) wet cure for balance of three days.

  Otherwise three days minimum.

- Release of falsework — load bearing:

Item	Minimum No. of days		Minimum Portion of Design Strength
Sidewalk slabs not supported on bridge	—		70%
Pier cabs with continuous support	3	and	60%
Pier caps without continuous support; crossbeams; top slabs of box culverts; and inclined walls or columns	5	and	80%
Cast-in-place bridge girders/superstructure	14	and	80%
Slabs on wood or steel stringers or wood or steel prestressed concrete girders	10		80%
Arches	21		—

Finishing Formed Surfaces

The primary purposes of finishing formed surfaces are:

- To seal the surface from water and other elements that can rust or corrode metal ties and reinforcement within the concrete.
- To provide a uniform, pleasing appearance for surfaces that will remain visible to the public.

Class 1

Class 1 finish is applied to concrete members to limits shown in the contract plans. The finish should be appealing to the eye with no large surface voids.

Class 1 finish:

- Remove all bolts, lips and edgings
- Fill holes greater than 1/4 inch with 1:2 mortar mix (Figure 5-1).
    - Cement used in mortar mix should contain the same brand of cement as what was used to make the concrete mix. This is to prevent color differences between mortar and concrete member.
- Wash surface to finished with water.
- Brush on a 1:1 mortar.
    - Brush on no more than what can be finish in that day.
- Rub off mortar with burlap sack or carpet (Figure 5-2).
- Fog spray finish to help set.
- Keep surface damp for two days.

Figure 5-1

Rubbing mortar mix in air pockets left after concrete placement.

Figure 5-2

Brushing off mortar mix from barrier.

Class 2

Class 2 finish applied to all above ground surfaces not receiving a class 1. With a Class 2 finish:

- Remove all bolts, lips, and edgings.
- Fill all form tie holes.

Backfilling 2-09.3(1)E

Backfilling is the final step in the basic concrete construction process. See that the structure is properly backfilled.

Ensure suitable material:

- Nonclay material.
- No material greater than 3 inches in diameter, frozen lumps, wood, or foreign materials.
- When specified in plans or approved by the engineer, controlled density fill may be used.

Timing:

- Generally after 14 days and 90 percent of design strength (particularly for one-sided backfill as for retaining walls).

  but

- Footings and columns may be backfilled as soon as forms removed if even and uniform on all sides.

Compaction:

- If under roadbed or part of roadway embankment:
  - Placed in layers of 6 inches (after compactions) or less.
  - Each layer compacted to 95 percent of maximum density.
- In other areas:
  - Placed in layers of 2 feet or less.
  - Each layer tamped and graded.
  - Compaction of controlled density fill not required.

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Part 6

Introduction to Bridge Foundations

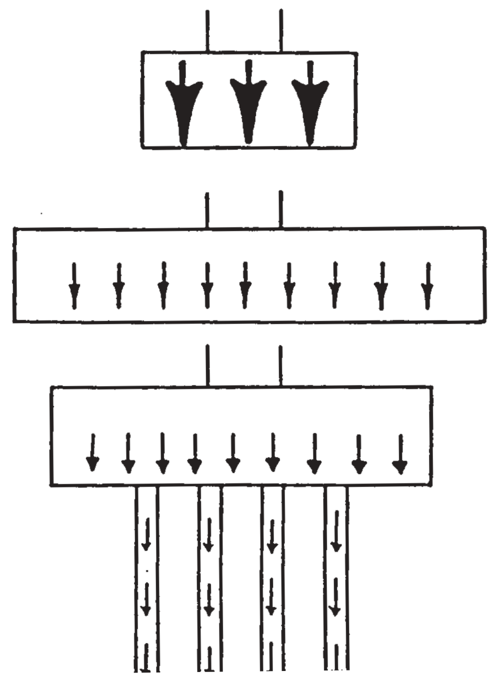
- **_Structure Excavation_**
  - *Classification of Structure Excavation*
  - *Preliminary Duties of the Inspector Before Excavation Begins*

- **_Types of Excavation Situations_**
  - *Open Pit “Glory Hole” Excavation*
  - *Basic “Dry” Excavation*
  - *Foundations on Rock*
  - *Shoring or Extra Excavation Class A*
  - *Wet Excavation*
  - *Piling*

Part 6 Introduction to Bridge Foundations

FOUNDATION FEATURES

- Basic Concrete Footing
- Spread Footing
- Pilings & Drilled Shafts
  + Pilings -- driven into ground
  + Drilled Shafts -- hole drilled into ground and filled with concrete (usually reinforced)



Structure Excavation

Classification of Structure Excavation

Class A — Required for bridge footings, pile caps, seals, wing walls, and retaining walls. If the excavation requires a cofferdam and/or shoring or extra excavation, the work outside the neat lines of the struc ex Class A shall be classed as shoring or extra ex Class A.

Class B — All other excavation.

Types of Excavation Situations

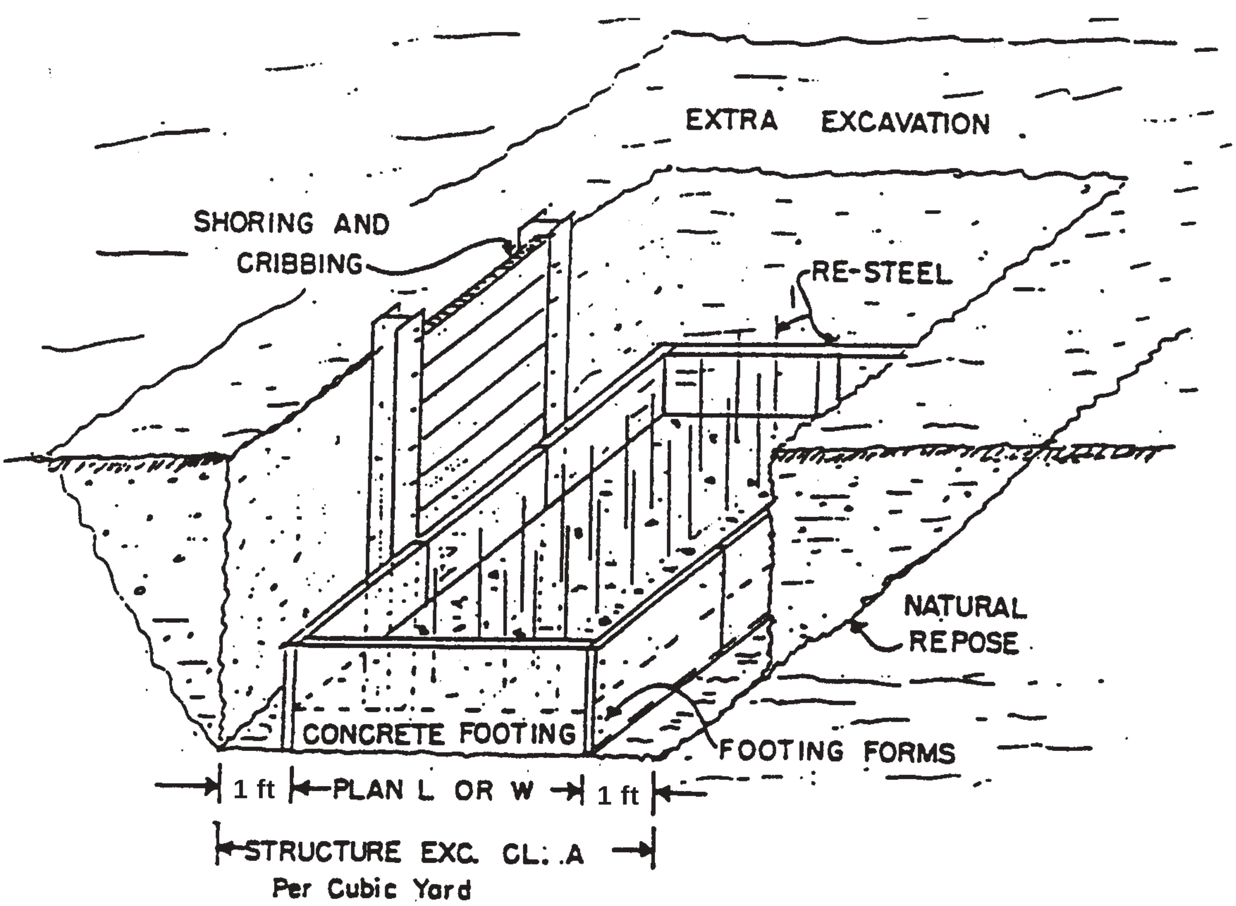
Preservation of Channel

When foundations or substructures are to be built in or next to running streams, the Contractor shall:

Excavate inside cofferdams, caissons, or sheet piling.

Never disturb natural streambed.

Backfill after foundations are placed to level of original streambed to prevent scouring.



Remove any excavation material that may have been deposited in or near the stream.

Maintain water depth and horizontal clearances for traffic to pass on navigable streams.

Place riprap around outside of cofferdams.

Preliminary Duties of the Inspector Before Excavation Begins

Have Stakes Set

Discussions with contractor prior to setting stakes will ensure workability.

Cross Section Excavation Area

Check plans, boring logs, and special provisions to ensure excavation limits.

Ensure Location

Visual inspection and references to centerline are best.

Read Soils Log (Borings)

Check water table and look for unsuitable to be removed below the footing.

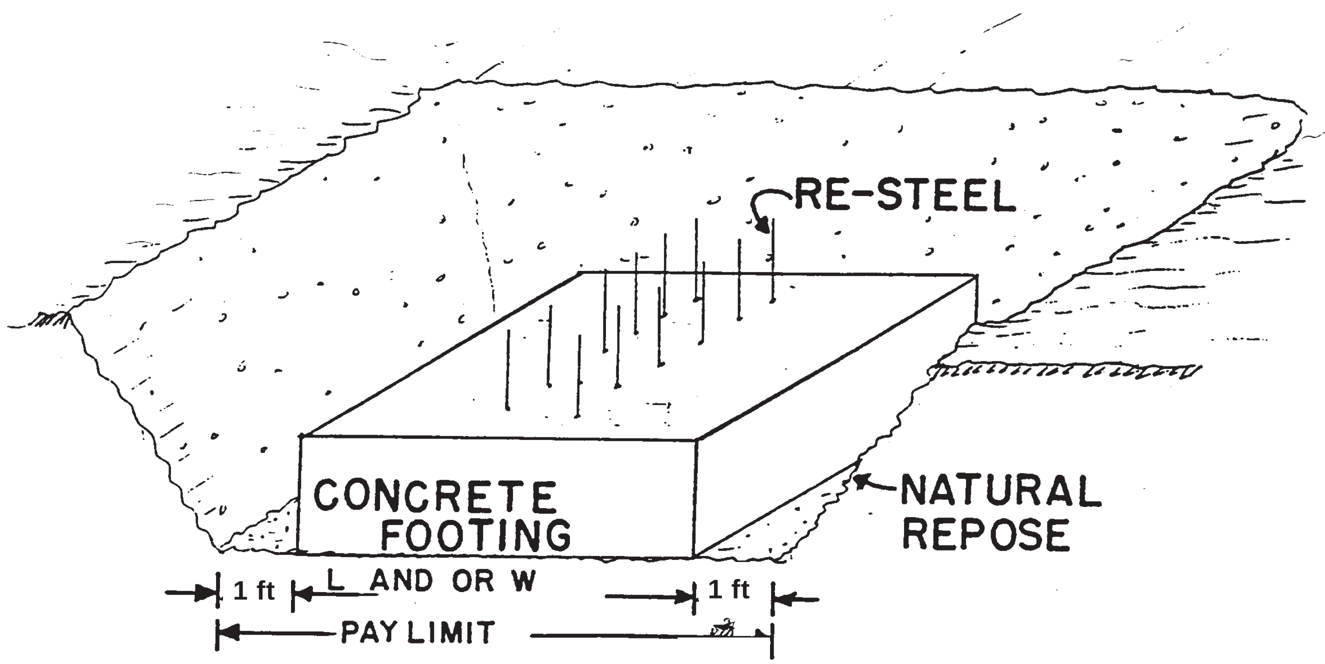
Verify Approval of Shoring and Cribbing Plans and Materials

Excavations greater than 4 feet in depth shall be shored or protected by cofferdams or meet requirements of *Standard Specification* 2-09.3(3)B.

Open Pit "Glory Hole" Excavation — Standard Spefification 2-09.3(3)B

Permitted (without shoring, etc.) if:

- Not under or near water.
- Material (and slopes of sides) adequately stable to ensure worker safety (required by law).
- Any groundwater can be adequately controlled to construct the footing in dry material.
- No threat to welfare of nearby existing structures or structure under construction.



"Glory Hole"

Basic "Dry" Excavation

Original ground cross-sectioned before excavation begins.

Check correct position and preserve offset reference points.

Any shoring, etc., constructed in accordance with contractor's approved plans.

Examine material for use as backfill:

- If suitable, see that stockpiled backfill is protected from contamination.
- If **not** suitable, must be disposed of at approved site.
- Dimensions of excavation:

  Wide enough for safe space for workers, forms, etc., (with sloped sides for safety if not shored).

  To depth specified for bottom of footing.

  For any structure foundation, bottom of excavation must be:

  ✓ Firm.

  ✓ Level.

  ✓ Uniform.

  ✓ Free of loose material.

  If native material is stable:

  ✓ It may remain as foundation.

  ✓ It must not be disturbed except to trim to desired grade.

  If native material is not stable:

  ✓ It must be removed and replaced with gravel backfill.

  ✓ Gravel backfill must be placed in layers of not more than 6 inches.

  ✓ Each layer must be compacted to 95 percent of maximum density.

  ✓ Backfilled with lean concrete.

  Any foundation must be approved by the engineer before any concrete placement.

Foundations on Rock

If rock encountered at planned elevation for bottom of footing, rock must be excavated:

- So that footing will key into rock.
- At least 1 foot deep.

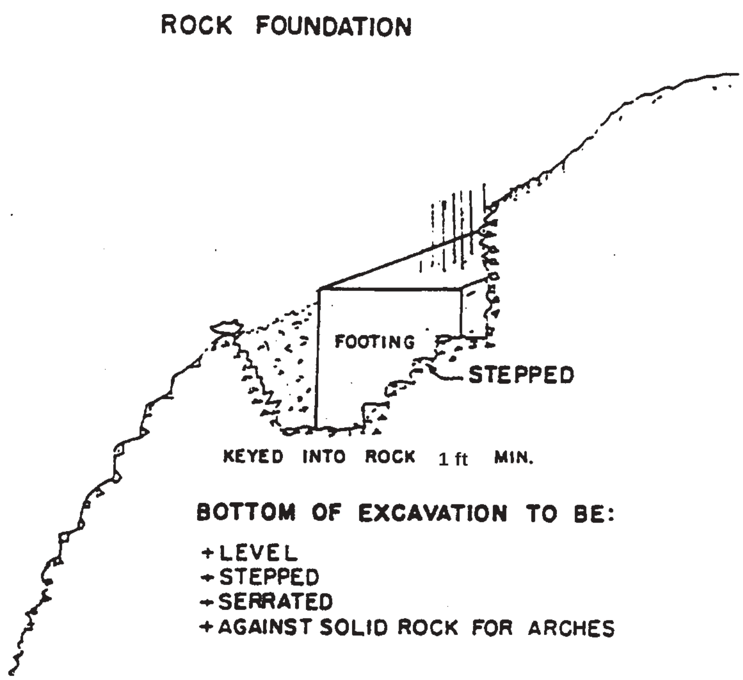
Rock surface for bottom of footing must be:

- Firm and solid.
- Free of loose material.
- Cut either:

  level,

  stepped, or

  serrated.



Shoring or Extra Excavation Class A

Required to support structure excavation when:

- Excavation is more than 4 feet deep.
- The excavation is completed to the structure excavation limits as specified in the plans (as shown in the example below) and including:

  The correct elevation for the bottom of the structure along the “neat line” at the bottom of the excavation.

  Adequate space for forms and workers outside the sides of the structure (usually about 1 foot outside).

Wet Excavation

Wet excavations will be discussed in detail in Section 8.

Piling

Piling will be discussed in detail in Section 7.

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Part 7

Pilings and Drilled Shafts

Part 7 — Pilings and Drilled Shafts

Introduction to Pilings

Pilings provide foundational support by serving as anchors that extend into the ground beneath the structure. They are typically used in locations where soil conditions near the bottom of the structure's foundation would not provide adequate bearing for a concrete footing. The types of piles to be used on a contract will be specified in the plans.

Types of Piling

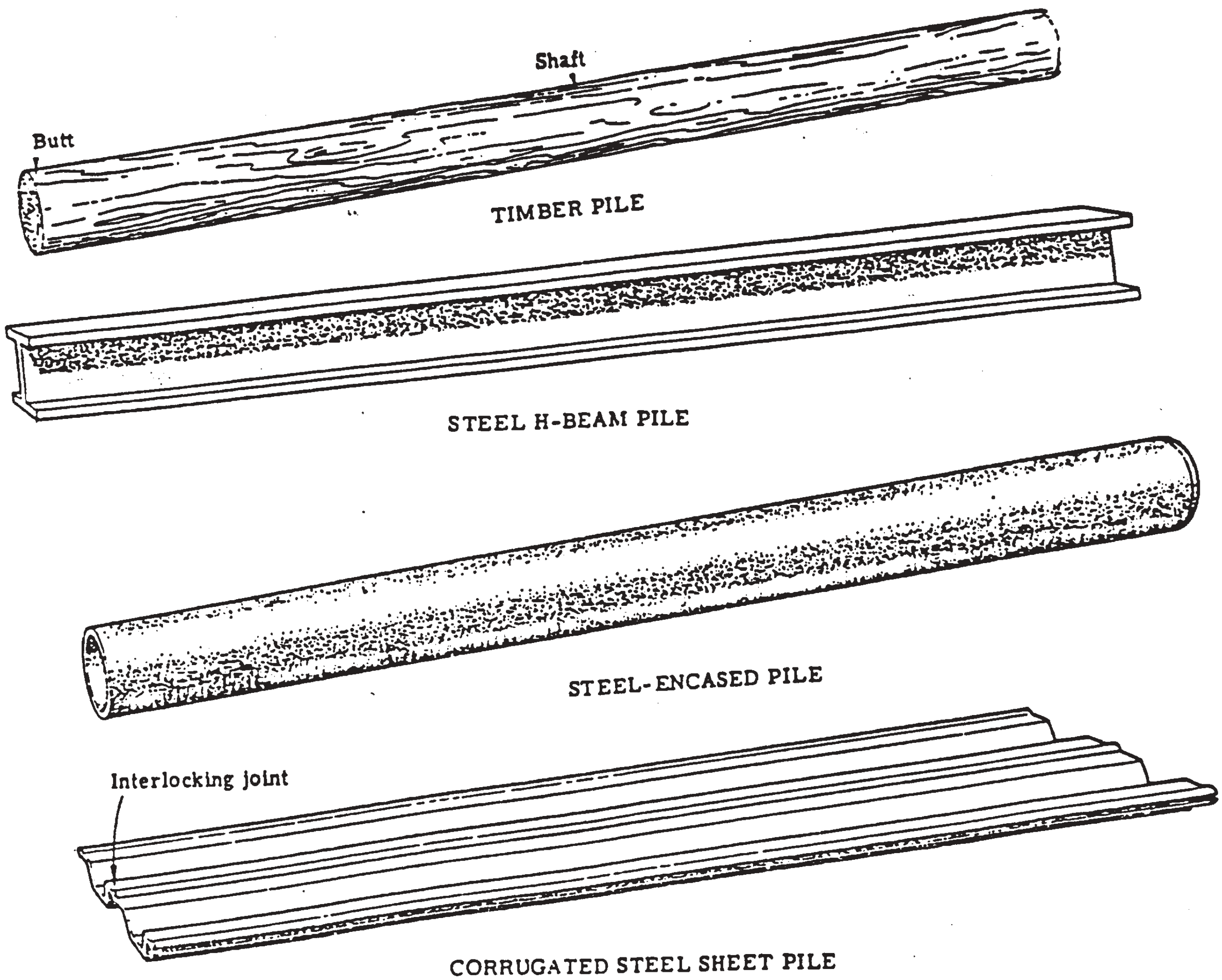
Timber shall be either treated or untreated. Pilings for foundations will be preferably Douglas Fir.

All timber piles shall be strapped with three straps: one approximately 18 inches from the butt, one approximately 24 inches from the butt, and one approximately 12 inches from the tip. Additional straps shall be provided at 15-foot centers between the butt and tip. Treated timber piles shall be strapped after treatment.

Steel H Piles — forged steel beams with an H-shaped cross-section.

Precast concrete piles — either precast concrete or precast, prestressed concrete driven to the minimum load bearing capacity called for in the plans.

- Cast-in-place concrete piles — consist of cylindrical steel shells that are driven into the ground and then filled with concrete. The piles are usually reinforced.


Shaft
Butt
TIMBER PILE
STEEL H-BEAM PILE
STEEL-ENCASED PILE
Interlocking joint
CORRUGATED STEEL SHEET PILE

Pile Driving Equipment

Prior to driving any piles, the contractor shall submit to the engineer for approval the details of each proposed driving system. The pile driving system shall meet these general requirements;

- Must have rigid fixed leads (Figure 7A).
  - The lead is the part of the pile driving equipment that holds the pile in place and controls the angle that the pile is drove. If a semi or swing lead is approved a template (Figure 7B) or pile driving analyzer may be required.
- Leads must be long enough to hold piles during driving.
- Driving head that prevents damage to the top of the piling.
- Pile driving system shall meet the requirements for the various combination of hammer and pile types.
  - Check the *Standard Specifications* for the various requirements that need to be met for type of piling being drove.
- The contractor shall submit a wave equation analysis for piling with ultimate bearing capacities of 300 tons or greater.

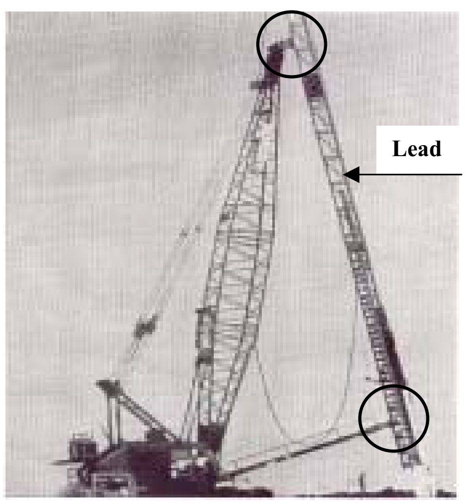
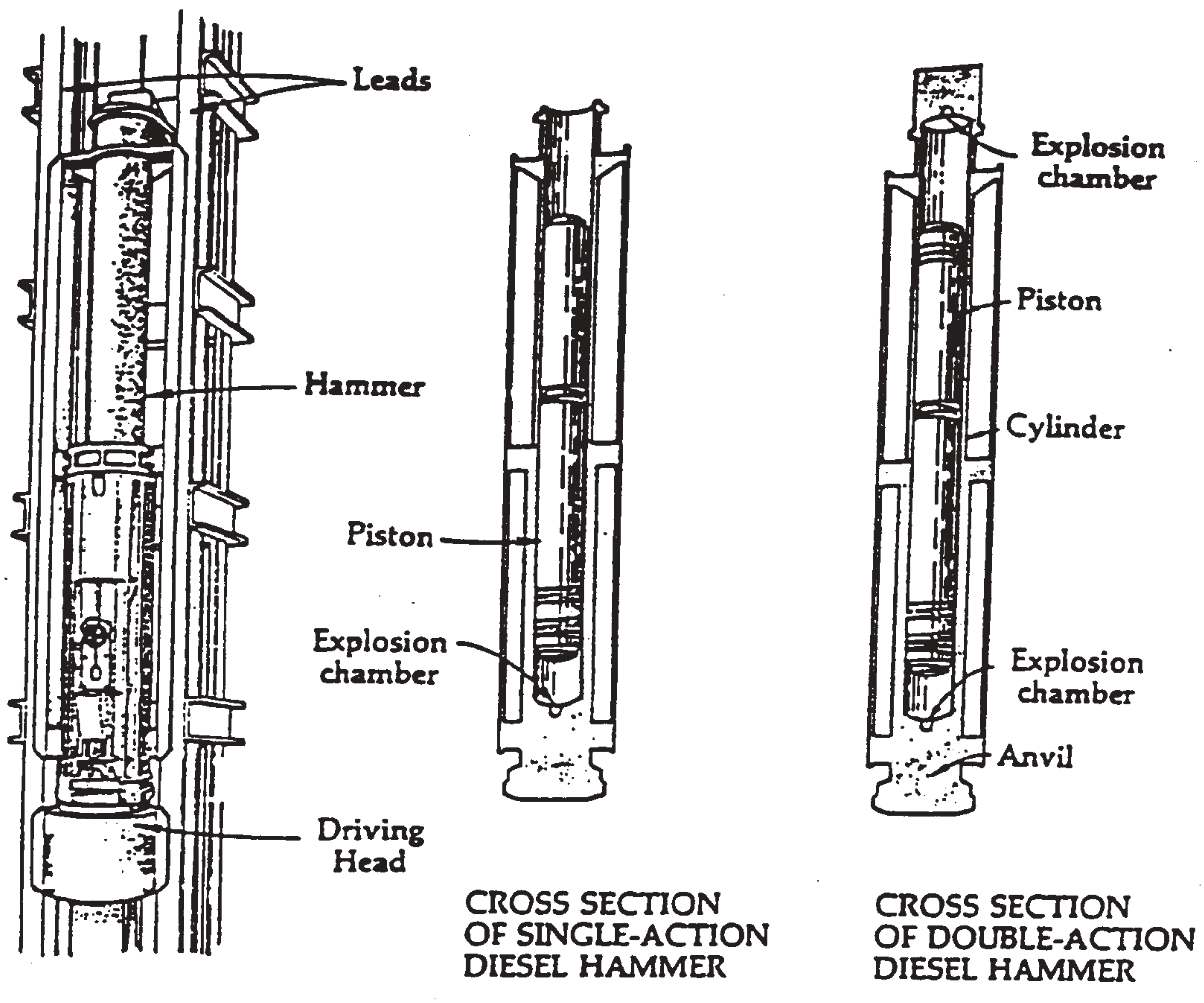


Figure 7A

Pile driver with rigid fix lead. A semi fixed lead would be only attached at the top or bottom and a swinging

Figure 7B

Steel "I" beams used as template for pile driving. The purpose of the template is to help guide the pile in the proper direction. A semi-fixed lead was used during this operation.



Pile Driving Equipment

Preparations for Pile Driving

In preparing for pile driving operations, you must first see that the site is ready, including:

- Completion of any excavation or embankment work so the site is at the correct elevation.
    - The contractor may leave the site elevation lower then the plan elevation to allow for heaving of the soils during pile driving operations.
- Accurate layout and staking of the entry points for the piles (Figure 7-1).
- Any specified pre-boring or jetting.
- Obtain and review contractors equipment submittals.
    - Field verify that the being used is what is on the contractors submittals (Figure 7-2). Including:
        - Rated capacity.
        - Hammer or Ram weight.
        - Hammer stroke of fall distance.
- Have bearing calculations ready for driving.
- As piling is delivered to the project inspect for acceptance.
    - Size and type as specified in plans.
    - For Steel (*Construction Manual* 9-4.39 and 9-4.40):
        - Certificate of Compliance.
        - Heat numbers on casing matches Certificate.
        - Check for damage.

Figure 7-1

With center of footing stakes and reference point stakes the inspector can verify location for piles.

Figure 7-2

Certification plate on diesel hammer. Gives ram weight and energy at bounce chamber.

- For Timber (*Construction Manual* 9-4.37):
  - Check for damage.
  - Check for Approval tag.
  - Check for strapping (*Standard Specification* 9-10.1)
- For Concrete (*Construction Manual* 9-4.54):
  - Check for damage.
  - Check for Approved for Shipment Tag.
  - Check cross-sectional dimensions.

Prior to Driving

- Mark each pile at 1-foot intervals (Figure 7-3).
  - The inspector will count the blows per foot to determine the bearing value achieved.
- Check entry position.
  - Make sure the pile is within the footing and at the correct location. Verify that the pile is being drove in a vertical position or at correct batter angle.
- Monitor driving.
  - Record blows for each foot drove. In soft material the initial blows may drive the pile more than 1 foot so record the distance the initial blows drove the pile. Count and record the blows per foot and hammer energy as the pile approaches bearing.

Steel can pilings marked in one foot intervals. Prior to driving all piling needs to be marked in one foot intervals. The inspector will count the blows per foot to determine the bearing value achieved.

Figure 7-3

Preparations – Pile Quantities

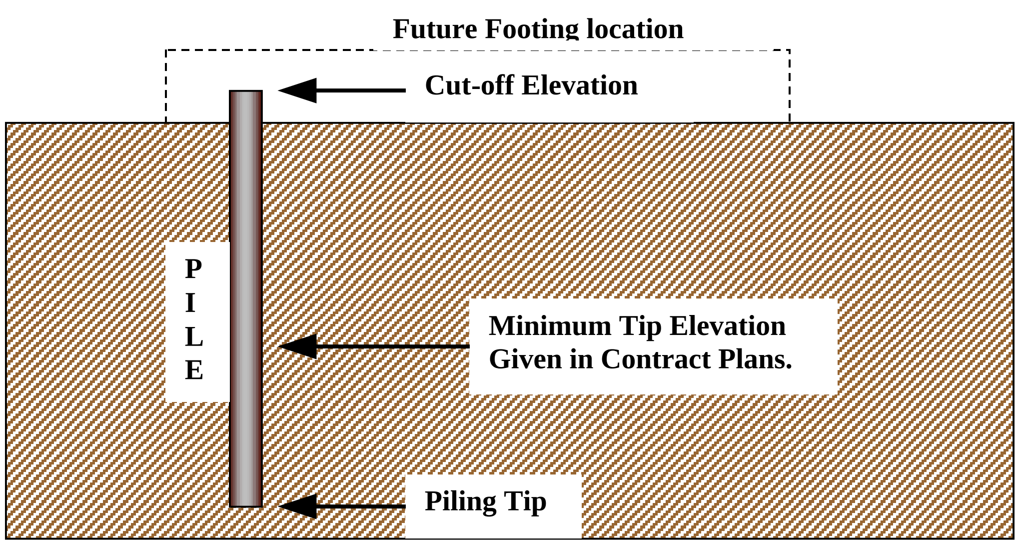
The number of piles is based on the number of piles required at each footing location. The length of the piling is based on the results of the test pile.

Test Piles

The purpose of the test pile is to determine the length of piling that will be needed from tip to cutoff to achieve the required bearing of the permanent piles. The contractor is responsible for the length of pile above the cutoff. The test pile also gives us information as to the conditions that may be encountered during driving of the permanent piles.

The test pile shall be the same type and size as the permanent piling.

- Timber Test Piles
  - Drove outside of footing area and cut off 1 foot below ground upon completion.
    - Timber piles are drove outside the footing in case the pile fails prior to reaching bearing. It is difficult if not impossible to remove timber piling from the ground once drove.
- Steel and Concrete Piles
  - May be drove within footing area and be considered a permanent pile. Unlike a timber pile, steel and concrete piles are easier to remove from the ground if required.
- Drive to the specified bearing plus 15 percent (except when using wave equation).
- Drive to minimum tip elevation or 10 feet below footing (15 feet below seal) if no minimum tip elevation is specified.



Cross Section of Drove Pile

Determination of Bearing Values 6.05.3(12)

English Units

P = F x E x Ln (10 N)

P = ultimate bearing capacity, in tons

F = 1.65 for air/steam hammers

= 1.55 for open ended diesel hammers

= 1.2 for closed ended diesel hammers

= 1.9 for hydraulic hammers

= 0.6 for drop hammers

E = developed energy, equal to W x H[1], in ft-kips

W = weight of ram, in kips

H = vertical drop of hammer or stroke of ram, in feet

N = average penetration resistance in blows per inch for the last 4 inches of driving

Ln = the natural logarithm, in base "e"

SI Units

P = F x E x Ln (10 N)

P = ultimate bearing capacity, in kilonewtons

F = 11 for air/steam hammers

= 10 for open ended diesel hammers

= 7.9 for closed ended diesel hammers

= 13 for hydraulic hammers

= 4.0 for drop hammers

E = developed energy, equal to W x H[1], in kilonewton-meters

W = weight of ram, in kilonewtons

H = vertical drop of hammer or stroke of ram, in meters

N = average penetration resistance in blows per 25 mm for the last 100 mm of driving

Ln = the natural logarithm, in base "e"

[1]For closed-end diesel hammers (double-acting), the developed hammer energy (E) is to be determined from the bounce chamber reading. Hammer manufacturer calibration data may be used to correlate bounce chamber pressure to developed hammer energy. For double-acting hammer hydraulic and air/steam hammers, the developed hammer energy shall be calculated from ram impact velocity measurements or other means approved by the Engineer. For open-ended diesel hammers (single-acting), use the blows per minute to determine the developed energy (E).

Pile Splices and Extensions

Pilings are usually provided in sufficient lengths to reach the depths indicated in the plans. However, splicing is sometimes needed in such situations as when the required bearing value cannot be achieved at the planned depth.

For steel piles and shells:

- Minimum distance of 10 feet between welded splices.
- Approval of the Engineer required.

For composite (untreated and treated) timber:

- Untreated portion to water or ground line.
- Pipe and spikes or bolts, etc., per plans.

For pre cast concrete:

- Extensions/buildups per plans.
- After driving complete.

Pile Cutoffs

After pile driving is completed, all piles must be cut off to the elevation specified by the plans. During pile cutoff operations, see that pilings are:

- To specified elevations.
- Parallel to bottom of footing.
- For treated timber — two coats of sealer and covered with approved roofing asphalt and a waterproofing fabric.

Completing Cast-in-Place Concrete Piles

For cast-in-place concrete piles, the driving of the steel shells is only part of the construction operation. After the shells are driven:

Inspect the interior of each shell thoroughly:

- By using the light that must be provided by the contractor.
- Seeing that there are no kinks, dents, water, or other foreign — materials in the shell.

Inspect the reinforcement, including:

- The sizes, lengths, spacings, splices, dimensions, or other requirements before installation into the shell.
- The in-place clearances after installation.

Inspect the concrete placement as for other structures, including:

- Proper mix 4,000 P 7-inch maximum slump (9-inches with HRWR).
- Vibration of top 10 feet required.
- In all cases, at least 5 feet below original ground line must be vibrated.
- Avoid pour delays.
- Curing.

Drilled Shaft Construction

Preparation

Review the Plans, Specifications, and Geotecnical Report for the project.

Discuss the expected ground conditions and construction methods with the Geotechnical Branch of the Materials Lab.

Review the *Drilled Shaft Inspectors Manual* prepared by the Association of Drilled Shaft Contractors (ADCS).

Submittals

The Special Provisions require detailed and project specific submittal. Documentation prior to commencement of shaft construction. While the formal approval of submittals will be provided by the Headquarters Bridge and Structures Office, Construction Support Group, the submittals should also be reviewed by the inspector for conformance with the Special Provisions. The inspector should become familiar with the submittal information, particularly:

- Names and qualifications of Contractor's personnel
- Proposed shaft installation plan
- Proposed construction sequence
- Proposed equipment and excavation methods
- Proposed methods to ensure excavation stability (casing, slurries, etc.)
- Details of proposed casing installation and removal methods/sequencing
- Reinforcing steel shop drawings
- Concrete placement procedures
    - Ensure plan includes rebar cage stability

Contractor's Installation Plan

It is the Contractor's responsibility to determine means and methods of construction of the drilled shafts and submit the proposed methods in accordance with the plans and specifications. It is the inspector's responsibility to ensure the approved methods are followed.

Shaft Pre-Construction Meeting

The Special Provisions require a shaft pre-construction meeting with the Project Engineer, the Inspector(s), and the Contractor. The Prime Contractor and any Specialty Contractors important to the shaft construction should be present.
In addition, a representative of OSC Construction should be invited.

Casing

It is the contractor's responsibility to provide casing (either temporary or permanent) which is strong enough to resist all transportation, handling, installation and removing stresses. The construction joint for the overlap of the shaft reinforcing cage and the column reinforcing is usually some distance below the ground surface. A short piece of casing is generally specified extending down from the ground surface to facilitate this construction joint.

There are two types of casing, permanent and temporary. Permanent casing is casing that will remain in the ground upon completion of drilling the shaft. Temporary casing (Figures 7-4 and 7-5) is casing that must be removed upon completion of the shaft. Temporary casing can be removed during concrete placement or near the end of the placing the concrete within the shaft.

The general requirements for casing are:

- Strong enough to resist stresses during transportation, handling, installation, and removing.
- Watertight.
- No telescoping except as allowed by the contract.

Figure 7-4

King Kong vibratory hammer placing temporary casing.

Figure 7-5

Welding extension to temporary casing.

Wet or Dry Shafts

When the bottom of the shaft may be caving, heaving or have water (Figure 7-6) entering into the shaft, the shaft can be drilled and poured using the wet hole method, where a controlled slurry is used to stabilize the hole with or without casing.

The method to be used will be determined by the contractor and included in the contractors' submittal.

Slurry

Controlled slurries my be of mineral (e.g. bentonite) or synthetic (e.g. polymer) nature. The purpose for using slurry is to help bind the fines together in a wet shaft so that the auger can bring the material out. All controlled slurries made of proprietary products must be used in accordance with the manufacture's recommendation. The Special Provisions required that a representative of the slurry manufacturer be on site during mixing and proportioning to ensure proper use of the controlled slurry.

Be aware that the contractor is responsible for the containment and disposal of slurry.

Excavation

During the excavation the inspector should keep track of the amount of time the contractor takes for drilling of the shaft. By doing this the if an obstruction is encountered a check of production rate can be compared to verify that working on force account is warranted. The inspector should be aware of the following excavation requirements;

- Proper location and tolerances.
- Once started the operation is continuous.
- No open holes overnight unless encased full depth and covered or backfilled.
- How to deal with obstructions.

Figure 7-6

Water encountered before reaching final tip elevation.

Clean-out bucket for cleaning bottom of shaft. Note water coming from bucket.

Special bucket used to remove cobbles from shaft. Cobbles may slow production or could be considered an obstruction.

Beginning of augering of shaft inside temporary casing. Note the spare auger sitting next to operation.

Concreting

Prior to placement of concrete, the shaft bottom should be checked for proper depth (Figure 7-7) and conformance with the tolerable amount of bottom sediment or spoils. The sand content (Figure 7-10) of shafts constructed using wet (slurry) methods must be checked in accordance with the Special Provisions.

Clean-out bucket used to prepare bottom of shaft.

Figure 7-7

Prior to placement of resteel depth of shaft needs to be verified. Here the contractor is using a weighted rag tape to verify depth.

Resteel

Placing resteel cage (Figure 7-8) and Cross Sonic Log (CSL) tubes (Figure 7-9):

- Secure resteel cage (especially important when temporary casing is being removed).
- Check resteel cage bracing and clearance spacers.
- Verify that CSL tubes are in place when required and tied securely.
- No welding on main bars (except where shown in plans).

Figure 7-8
Placing resteel case down shaft.

Figure 7-9
Shaft resteel with CSL tubes.

Concrete Placement

Commence placement of concrete immediately after excavation of shaft and placement of resteel. If water was encountered a sand test is required to be performed by the contractor to verify that there will not be an excess amount of sediments in shaft.

If there is water within the shaft then a rigid conduit (Figure 7-11) must be used to place the concrete. The end of the conduit must stay inside the concrete maintaining a positive head of at least 5 feet above the end of the conduit (Figure 7-12).

If the shaft is poured in the dry then a method of placement must be used that will allow the concrete to fall freely down the center of the shaft without concrete splashing against the resteel cage or segregation of the aggregate.

Maximum slump for shaft concrete shall be 9 inches when using 4000P provided that the water cement ratio does not exceed 0.44 and a water reducer is used meeting Section 9 requirements for the Standard Specifications.

If CSL tubes were installed in the resteel cage, the CSL tubes are to be filled with water immediately after concrete placement.

Figure 7-10

Performing silt test prior to placing concrete in shaft that has encountered ground water.

Figure 7-11

Rigid conduit being marked for length. This enables the contractor to verify that the end of the conduit is inside the concrete during placement.

Figure 7-12

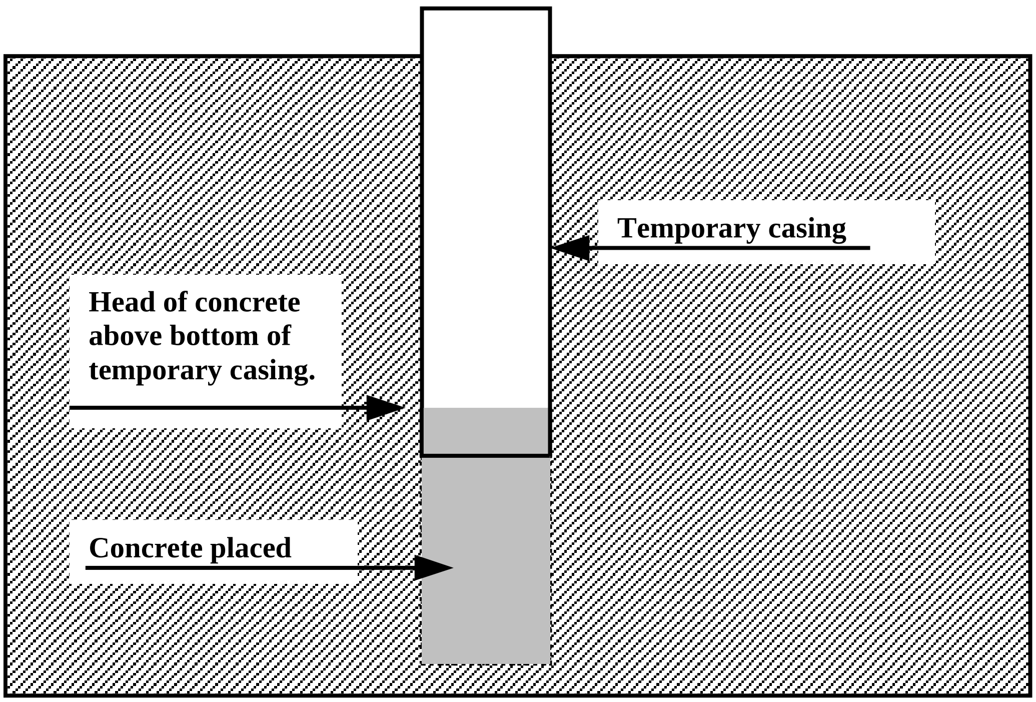
Concrete being placed by pump truck. Tremie from pump truck is attached to rigid conduit inserted to bottom of shaft through center of resteel cage.

Casing Removal

All temporary casings shall be removed unless approved other wise by FOSSC.

During the removal of the temporary casing the concrete head must be maintain above the bottom of the casing (Figure 7-13). If water is in the shaft the rigid conduit used for concrete placement must be within the concrete at least 5 feet and concrete above the temporary casing.

If temporary casing is removed need the end of the concrete placement the contractor should have additional concrete on hand to allow for the settlement of concrete as the casing is removed.



Cross Sonic Log Test

The “Cross Sonic Log” (CSL) test is a nondestructive analysis of the concrete that was placed within the shaft. The special provisions will indicate whether the testing will be performed by the contractor or by WSDOT personnel.

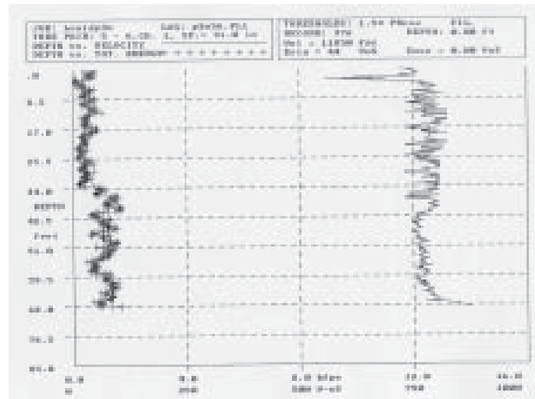
The Special Provisions will tell the minimum number of shafts to be tested. In most cases:

- 50 percent of the shafts are to be tested.
- The first shaft drilled will require CSL testing.
- A minimum of one shaft per pier is to be tested.

The testing will occur after at least 24 hours. This may be extended if a retarding admixture was used in the concrete mix.

After the shaft has been tested and found to be acceptable the CSL tube is to be dewatered and filled with grout.

CSL receiver being placed into CSL tube.



Computer readout of CSL test. The spike in the reading on the right side is an anomaly within the shaft.

Part 8

Wet Foundations

- ***Basic Cofferdam Requirements***
- ***Preparations for Cofferdams***
- ***Driving Sheet Piles***
- ***Wet Excavation***
- ***Driving Foundation Piles***
- ***Placing Concrete Seal***
- ***Dewatering Cofferdams***
- ***Completing Construction***

Basic Cofferdam Requirements

A cofferdam is any watertight enclosure, sealed at the bottom, that surrounds the excavated area of a structure.

The contractor shall use cofferdams in all excavation that is underwater or affected by groundwater.

All cofferdams must:

- Extend well below bottom of excavation.
- Be watertight with adequate seal to construct footing “in-the-dry.”
- Be adequate size and space for specified dimensions of structures.

Preparations for Cofferdams

The contractor shall provide the engineer with plans showing proposed methods and construction details of cofferdams.

No work shall begin until the engineer approves the plan.

Driving Sheet Piles

A temporary guide structure is usually used (on temporary piles for most underwater situations).

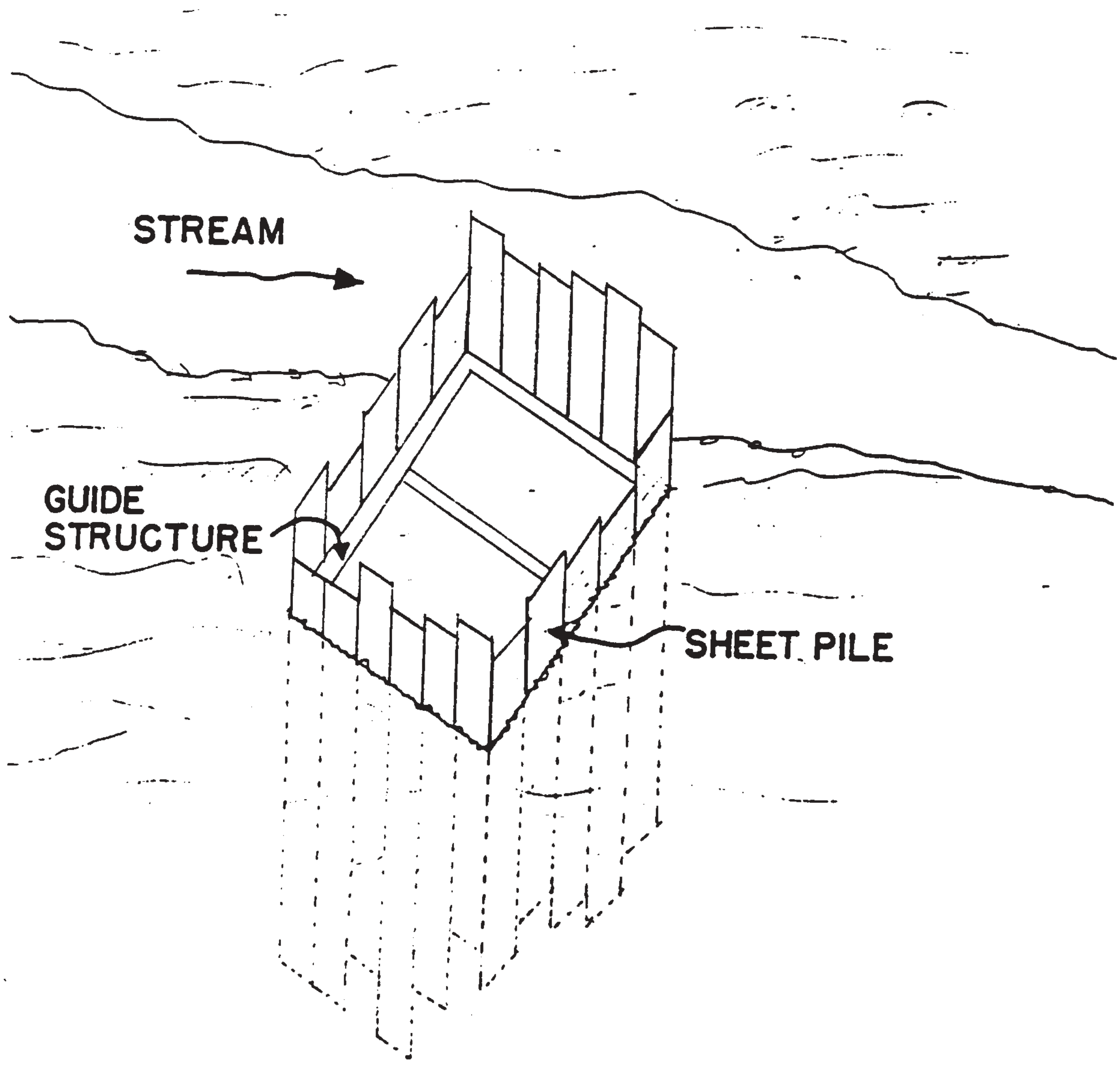
Usually deep-arch, interlocking sheet piles are used (see attached chart).

Start driving sheet piles at corner of cofferdam.

All sheet piles must be plumb.

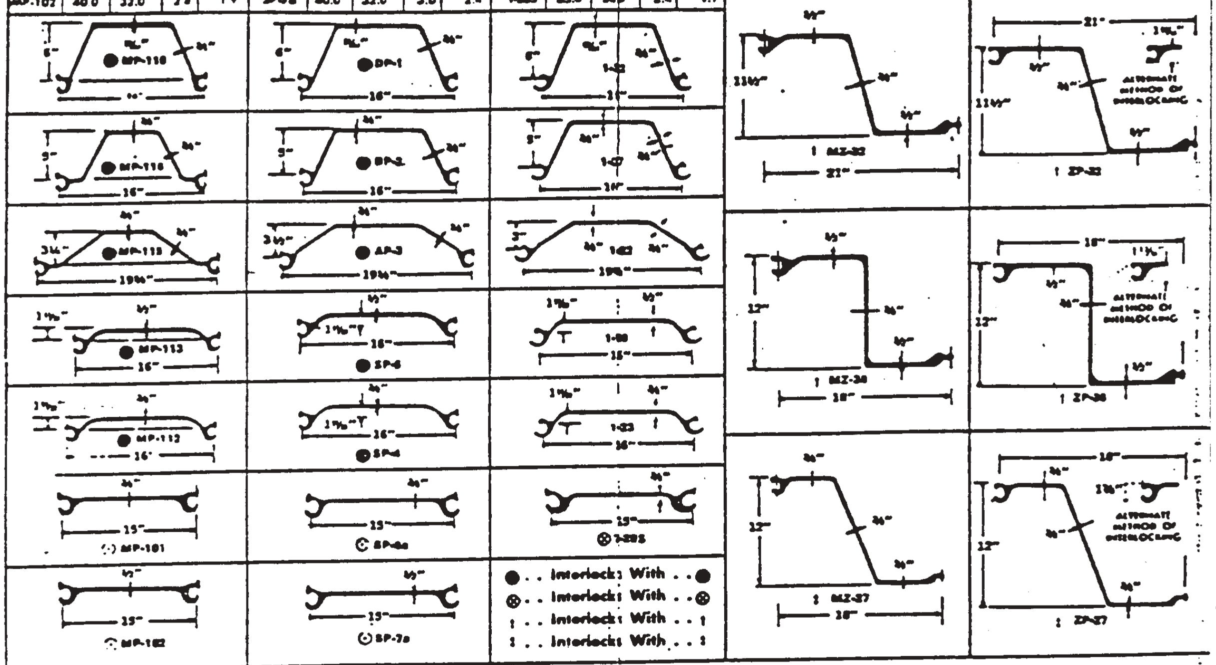
Drive each pile only ± 3 feet at a time and then move on to next sheet pile.

Continue progressively around cofferdam until planned depth achieved.


STREAM
GUIDE STRUCTURE
SHEET PILE

U. S. STEEL					BETHLEHEM					INLAND				
Section No.	Weight in lbs. Per lin. ft. of pile	Weight in lbs. Per Sq. ft. of wall	Section Modulus Inches Per Pile	Section Modulus Inches Per lin. ft. of wall	Section No.	Weight in lbs. Per lin. ft. of pile	Weight in lbs. Per Sq. ft. of wall	Section Modulus Inches Per Pile	Section Modulus Inches Per lin. ft. of wall	Section No.	Weight in lbs. Per lin. ft. of pile	Weight in lbs. Per Sq. ft. of wall	Section Modulus Inches Per Pile	Section Modulus Inches Per lin. ft. of wall
MP-110	47.7	32.0	20.4	15.3	DP-1	42.7	32.0	20.4	15.3	I-32	42.7	32.0	20.4	15.3
MP-116	36.0	27.0	14.3	10.7	DP-2	36.0	27.0	14.3	10.7	I-27	36.0	27.0	14.3	10.7
MP-115	36.0	22.0	8.8	5.4	AP-3	36.0	22.0	8.8	5.4	I-22	36.0	22.0	8.8	5.4
MP-113	37.3	28.0	3.3	2.5	SP-5	37.3	28.0	3.3	2.5	I-28	37.3	28.0	3.3	2.5
MP-112	30.7	23.0	3.2	2.4	SP-4	30.7	23.0	3.2	2.4	I-23	30.7	23.0	3.2	2.4
MP-101	35.0	28.0	2.4	1.9	SP-6a	35.0	28.0	3.0	2.4	I-285	35.0	28.0	2.4	1.9
MP-102	40.0	32.0	2.4	1.9	SP-7a	40.0	32.0	3.0	2.4					

U. S. STEEL					BETHLEHEM				
Section No.	Weight in lbs. Per lin. ft. of pile	Weight in lbs. Per Sq. ft. of wall	Section Modulus Inches Per Pile	Section Modulus Inches Per lin. ft. of wall	Section No.	Weight in lbs. Per lin. ft. of pile	Weight in lbs. Per Sq. ft. of wall	Section Modulus Inches Per Pile	Section Modulus Inches Per lin. ft. of wall
MZ-32	56.0	32.0	67.0	38.3	ZP-32	56.0	32.0	67.0	38.3
MZ-38	57.0	38.0	70.2	46.8	ZP-38	57.0	38.0	70.2	46.8
MZ-27	40.5	27.0	45.3	30.2	ZP-27	40.5	27.0	45.3	30.2



HAMMERS: McKiernan-Terry and Vulcan air-steam single and double acting impact hammers. McKiernan-Terry diesels.

EXTRACTORS: McKiernan-Terry, Vulcan and British Steel piling up to 17,000 foot lbs. energy — the largest and most powerful made.

VIBRATORY HAMMERS: McKiernan-Terry hydraulic, Muller electric — up to 144 hp for driving and extracting.

HAMMER ATTACHMENTS: A wide variety of standard and special drive caps, helmets, heads, anvils for steel-sheeting, H-beams, pipe and wood piles and caissons. Cushion material, studs, guide frames and skirts.

LEADS: All sizes and lengths of leads including swinging, hanging, extended and compression types. A-frame spotters with and without power, hairpins, telescopes, cradles with swivel where required and boom adaptions.

AIR COMPRESSORS: Ingersoll Rand portable diesel driven rotaries up to 1200 C.F.M. including units equipped with Supertherm After-Heater attachments for high pressure, 150 lb. applications.

JET PUMPS: Multi-stage, high capacity por able gasoline and diesel driven units up 1 1200 gpm and up to 600 psi. All accessorie available including jet hose, jet pipes, goos necks and nozzles.

DEWATERING PUMPS: Large high capacity dies engine driven centrifugal pumps up to 400 GPM for cofferdam dewatering.

WELLPOINT DEWATERING SYSTEMS: Foundatio Wellpoint Dewatering Systems using th patented free flow self jetting wellpoi for wet excavation work and cofferda dewatering.

Steel Sheet Piling Sections Produced in the United States

Wet Excavation

Generally, the same basic methods and requirement for structure excavation will apply except those affected by water.

The contractor must provide adequate bracing or support to prevent collapse before excavation begins.

The inspector must check material as excavated.

- When the material at the bottom of an excavation is not stable enough to support the structure, the contractor shall excavate below grade and replace the unstable material with gravel backfill.
- Gravel backfill shall meet the requirement of Section 9-03.12. It shall be placed in 6 inch lifts. Compaction shall be as required under Method C.

The inspector should take and record soundings to determine underwater elevations.

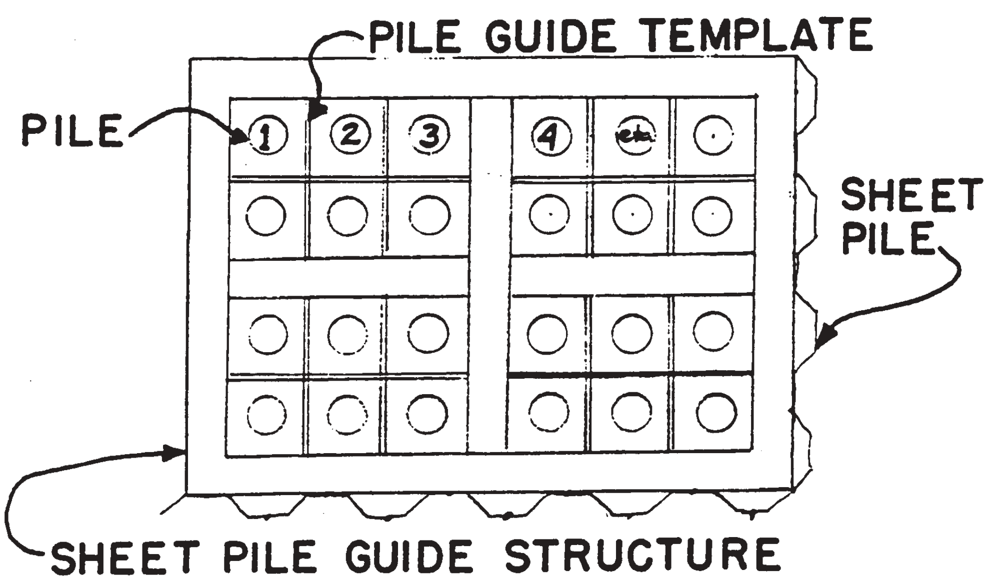
Driving Foundation Piles

Template often used.

- As a guide for pile location.
- To establish elevation references.

PLAN VIEW

GUIDE FOR PILE LOCATION IN COFFERDAM



Driving operations generally for other pile driving.

The inspector must:

- Check type of equipment and piling.
- Monitor penetration and bearing.
- Take soundings after driving to check for any soil displacement.

Placing Concrete Seal

When constructing foundations in streams and other locations below water, it is usually necessary to place a concrete seal in the cofferdam so that the cofferdam may be dewatered.

The thickness of the seal is based on the vent elevation shown in the plans.

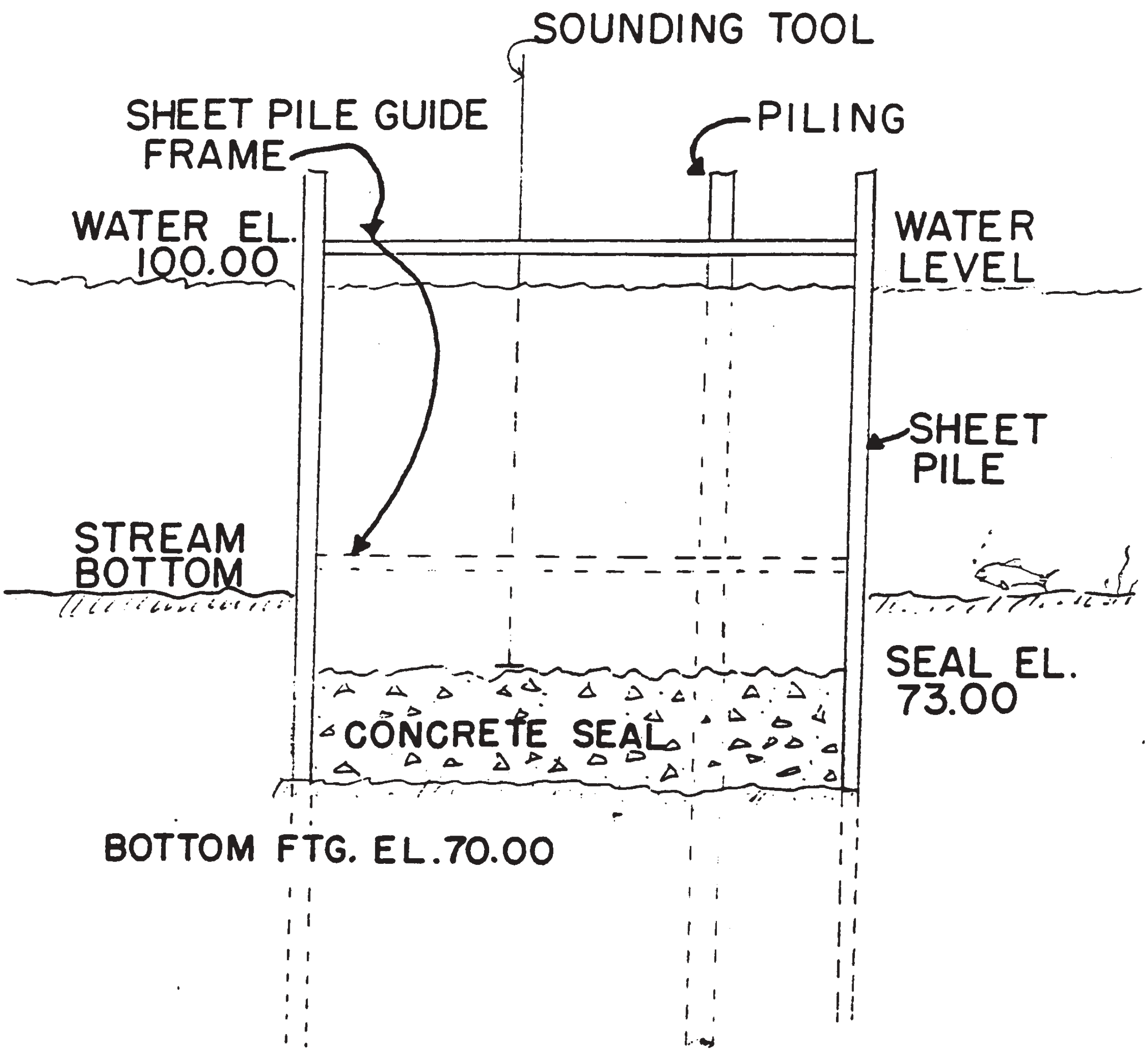
- Minimum thickness is 18 inches.
- Thickness without piling shall be not less than 0.43 times the height of water above the bottom of the seal.

Concrete placement requirements:

- Seal concrete shall be placed under water by means of a tremie or a concrete pump.
- Concrete pump discharge tubes and tremie tubes shall be fitted with a suitable plug to prevent water entry during initial charging of concrete.
- The concrete shall be placed continuously until the required seal is placed.
- Maximum slump for seal concrete is 7 inches.
- Tops of seals should be slightly sloped to one end.

Take soundings of the surface of the seal.

This illustration should give you a good idea of what we are talking about.


SOUNDING TOOL
SHEET PILE GUIDE FRAME
PILING
WATER EL. 100.00
WATER LEVEL
SHEET PILE
STREAM BOTTOM
SEAL EL. 73.00
CONCRETE SEAL
BOTTOM FTG. EL.70.00

Dewatering Cofferdams

Cofferdams must be vented at the elevation of the water which the designed thickness of the seal is based.

If seal is poured during high water, cofferdams may not be dewatered until level is below vents.

Cofferdams shall not be dewatered until concrete seal is placed and cured.

- Minimum curing time:

  3 days without piling.

  10 days with piling.

The contractor shall:

- Provide adequate pumps to remove water.
- Seal any leaking joints.
- Clean film of scum from seal surface before footing construction.

Completing Construction

Footing and pier constructed in the dry as in other situations.

Cofferdam flooded after concrete is cured.

Natural stream bed lines and grades restored.

12:P65:DP/BSI

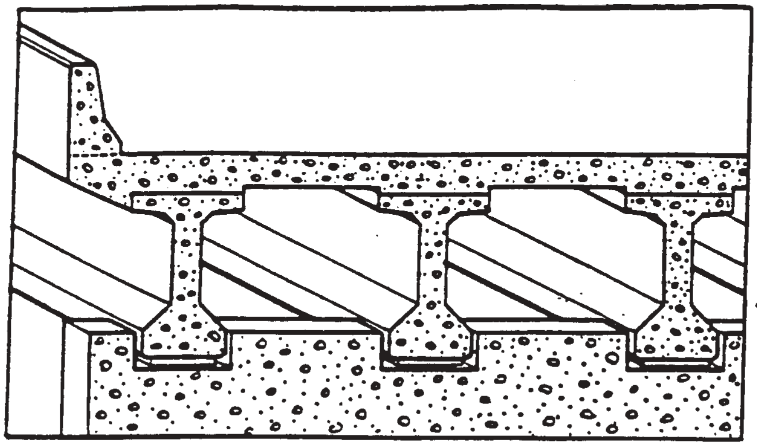
Part 9

Prefabricated Girders

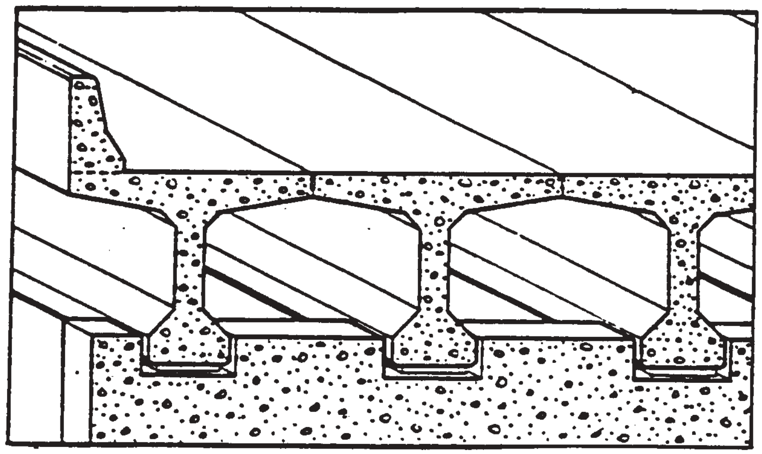
- ***Key Aspects of Bridge Girders***

- ***Prestressed Concrete***
  - *Basic I-Girder Construction*
  - *Girder Transport and Delivery*
  - *Erecting Girders*
  - *Constructing Diaphragms*
  - *Rigid Frame Construction*
  - *T-Girders*

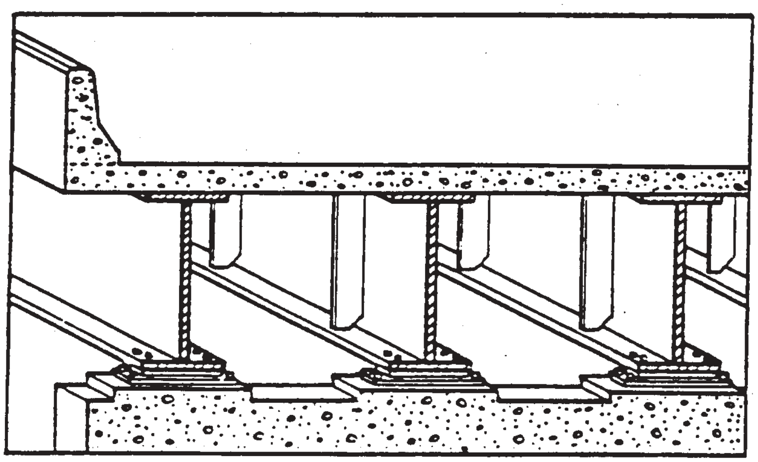
- ***Steel Girders***
  - *Preparation of Caps and Seats*
  - *Transport, Delivery, and Inspection*
  - *Final Bolting*
  - *Bolting Inspection*



PRESTRESSED CONCRETE I-GIRDERS



PRESTRESSED CONCRETE T-GIRDERS



STRUCTURAL STEEL GIRDERS

Types of Bridges

Key Aspects of Bridge Girders

The various types of girders generally share certain key characteristics, including bearing points, diaphragms, camber, and deflection.

As a general rule, one end of any span is designed as a fixed bearing while the other end provides for expansion. (See following page.)

Bearing joints are the points at which the ends of a beam or girder rest on the piers and abutments, as illustrated on the following page. Usually, some type of bearing pad or plate assembly is placed between the beam or girder and the top of the pier or abutment. Generally, this bearing device may be either:

- A *fixed* type of bearing that holds the beam or girder rigidly in place, or
- An *expansion* type that permits some slight longitudinal movement.

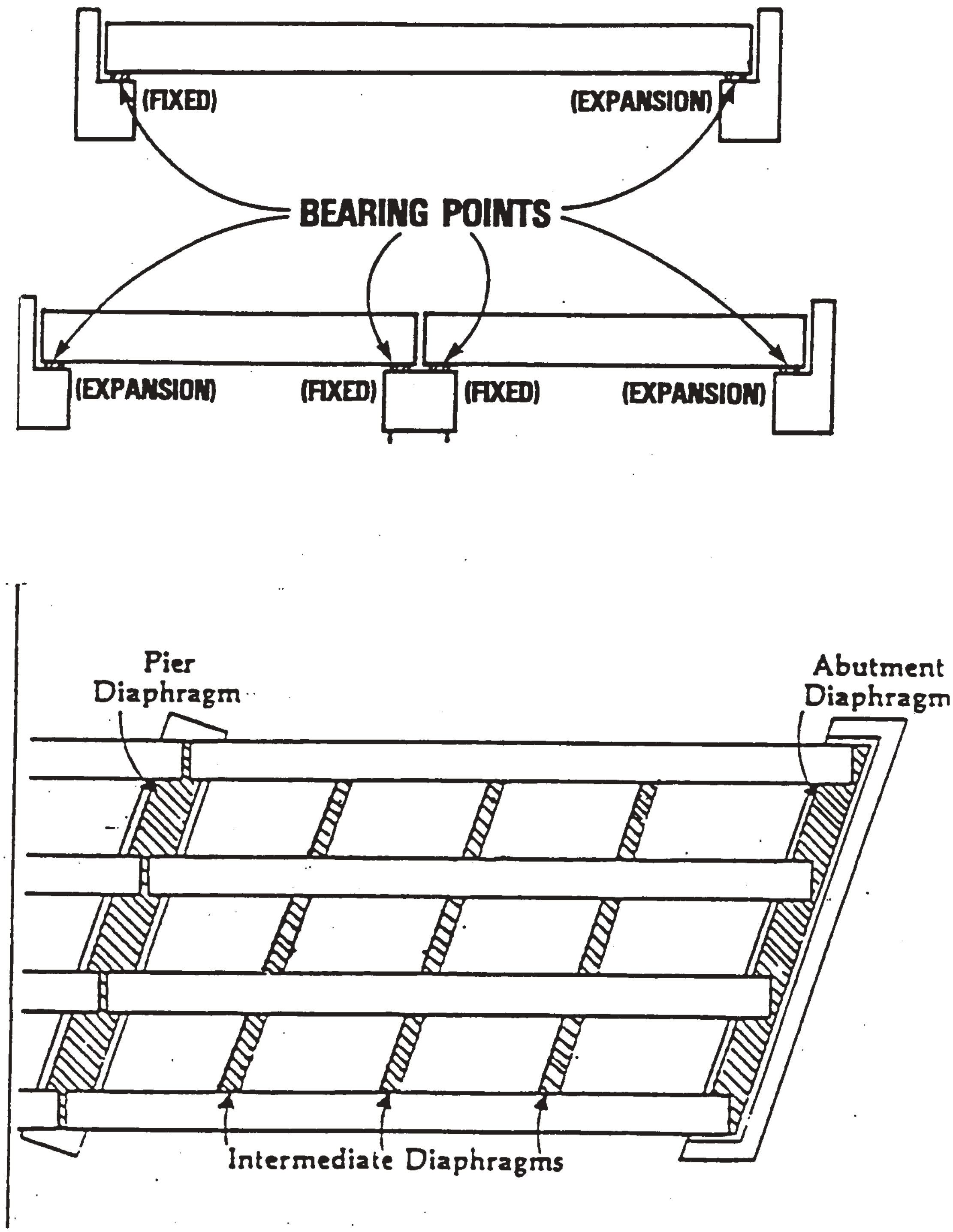
Diaphragms provide the beams or girders with lateral support, they include:

- Pier and abutment diaphragms, and
- Intermediate diaphragms.

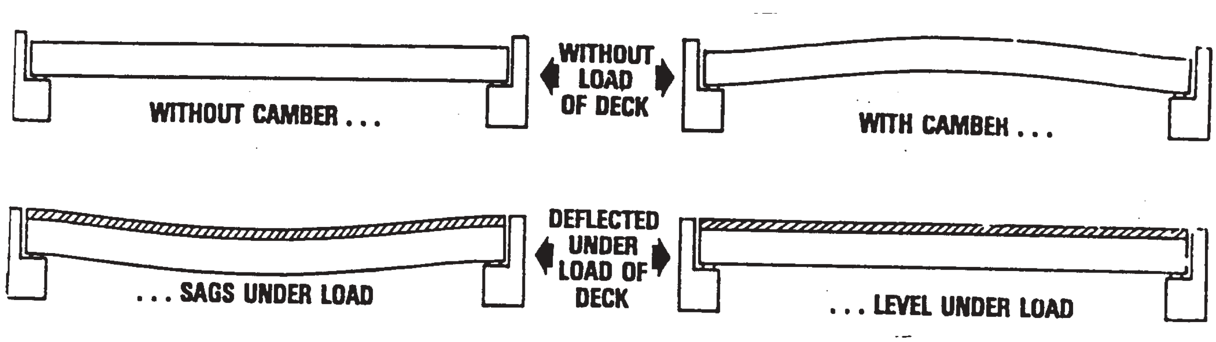
Camber and *deflection* must also be considered in the design and construction of bridge beams and girders. If a beam or girder is fabricated so that it is exactly straight and level, the weight of the diaphragms, deck, and other parts of the superstructure will deflect it so that it sags in the middle.

Camber and deflection:

- Camber — fabricated curvature of girder without load.
- Deflection — settlement under load of deck.



Bearing Points



Camber and Deflection

Prestressed Concrete

Basic I-Girder Construction

Preparation of Caps and Seats:

- Check cap construction for elevations and alignments of seats.

Bearing device as per plans:

- Grout pads (if required) must reach at least 2000 psi cube test.
- Elastomeric bearing pad (usually) secured with approved adhesive.

Girder stop blocks between girder seats.

Caps must attain 80 percent of design strength before girder erection.

Girder Transport and Delivery

As precast concrete beams are delivered to the site for erection, you should:

- See that they are kept in an upright position.
- Properly supported.

  Within 3 feet of ends for series W42G and W50G and all Bulb T.

  Within 4 feet for series W58G.

  Within 5 feet for series W74G.

  Within 8 feet for series W83G and W95G.

  The contractor may deviate from the support locations listed above provided he submits his proposal, with supporting calculations, to the engineer for review.

Lateral bracing to prevent buckling of long girders shall be in place during transportation and erection if required by 6-02.3(25)M.

Inspect girders for:

- Approved for Shipment stamp.
- General condition — cracks, exposed re-steel, defects.
- Lengths and cross-section.
- Alignment and camber.
- Through-holes and threaded inserts for diaphragms re-steel.
- Rebar extensions and roughened surface of top of girder.
- Lifting loops or devices.
- Size, spacing, and clearances of any falsework hanger block-out holes in upper flange.

Erecting Girders

As precast concrete beams are erected, your primary inspection concerns are to see that they are:

- Properly handled to avoid stress or damage.

  Proper type of rigging.

  Often, with close coordination of two cranes.

  Girder launchers as needed.

- Properly aligned and seated at each end.

Check plumb of girder web.

Brace when, where needed.

Constructing Diaphragms

Diaphragms provide lateral support and tie girders together.

Check diaphragms' re-steel — with threaded inserts in interior sides of outer girders and through-holes in others.

Open joints, girder stops, etc., at piers and abutments as per plans.

Typically:

- Intermediate diaphragms, first.
- Pier and abutment diaphragms later (sometimes with deck).

Rigid Frame Construction

Falsework:

- In accordance with approved falsework drawings.
- Falsework foundations:

  False piles usually required.

  Mudsills, if approved by engineer.

- Rigid, well-secured support system.
- Proper use and adjustment of wedges (in pairs), screws, jacks, etc.
- Sizes and spacings of stringers beams, etc.

Girder Delivery and Erection:

- Same as girders on caps.

Crossbeam Construction:

- Crossbeams constructed around girder ends to hold rigidly at tops of piers.
- Reinforced, formed, poured, and cured as for other cast-in-place concrete.
- Falsework removal:

  After at least five days and 80 percent of design strength.

  Before deck poured.

T-Girders

Caps and Seats Preparation:

- Similar to I-girders.
- Except when bearing seats are parallel to roadway grade.

Transport and Delivery:

- Same requirements. Inspect as I-girders, except:

  Check top of T-girders for:

  ✓ Finish as for deck.

  ✓ Straightedge tolerance of $^1/_4$ inches/10 feet.

Erection:

- Similar to I-girders plus:

  Care to get tight joints.

  Webs perpendicular to road surface.

Completing T-Girders:

- Cambers equalized with weights, jacks, etc. (no other equipment, etc., on deck).
- Diaphragms — cast-in-place concrete through temporary access holes or steel struts.
- Weld tying joint connections.
- Fill joint keyways with nonshrink concrete.
- Removal of camber equalization apparatus after:

  All weld tying is complete.

  Diaphragm and keyway concrete are at least 4,000 psi strength.

Steel Girders

Preparation of Caps and Seats

Accurate construction of girder seats to specified lines and grades.

Check bearing devices:

- Specified fixed, expansion, sliding, or rocker types per plans.
- Dimensions, positions, etc., of embedded anchor bolts.
- Shim stock to set lower plates to specified elevations.
- Bearing surfaces milled true.
- Upper plates, etc., ready for girder.

Cap must reach 80 percent of design strength.

Transport, Delivery, and Inspection

As the girders, diaphragms, and connecting hardware are delivered to the site, you should:

- Inspect girders and diaphragms for:

  General condition, twists, or defects.

  ✓ Damage must be corrected before member is placed.

  Loose rust or scale; shop coat of paint.

  Dimensions, etc., per plans and shop drawings

  ✓ All members dimensioned at 65°F.

  Erection marks. (Erection plan required.) (6-03.3(7)A)

  Properly handled.

  Accurate seating at each end.

  Proper alignment and camber.

  Initial girder and diaphragm connections.

  Throughout construction contact surfaces must be kept free of paint grease or other foreign material.

  Partial bolt until complete span is in place.

  ✓ Normal structures. Fifty percent full strength with at least 30 percent of holes pinned in any joint

  ✓ Cantilever structures. Seventy-five percent full with at least 50 percent of holes pinned in any joint.

Final Bolting

High-strength nuts, bolts, washers, etc. Sizes and grades per plans.

Tighten systematically from center out:

- Turn of the nut (see Table 4, 6-03.3(33)).
- Using direct tension indicator (do not put under turned element).

Bolting Inspection

The contractor in the presence of the engineer checks tightened bolts with a torque wrench.

- Ten percent (at least two) bolts in each connection.
- Contact surfaces free of paint, grease, or other foreign material.
- Heads on the outside and underside.
- Washers on the head and nut sides.

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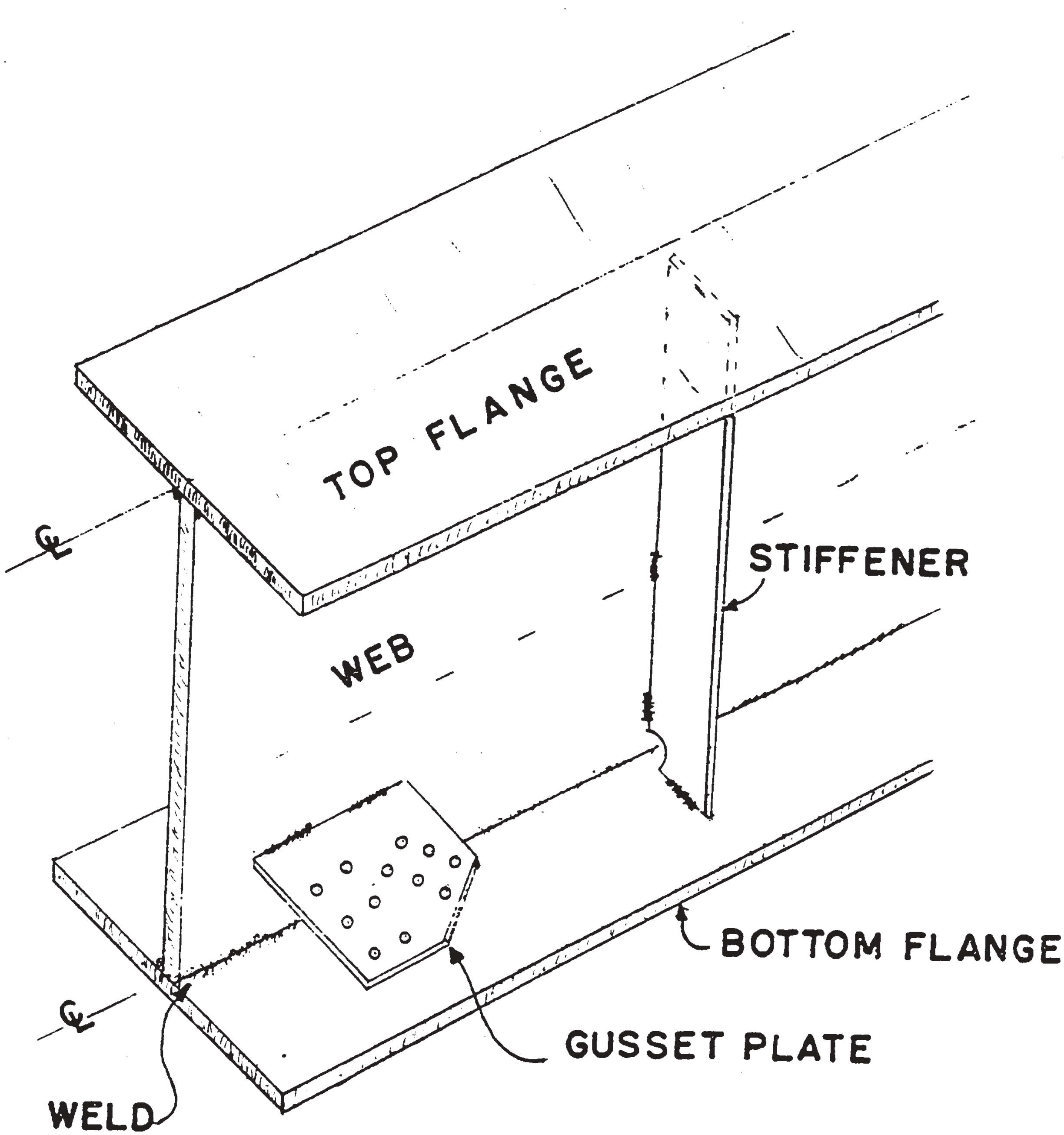
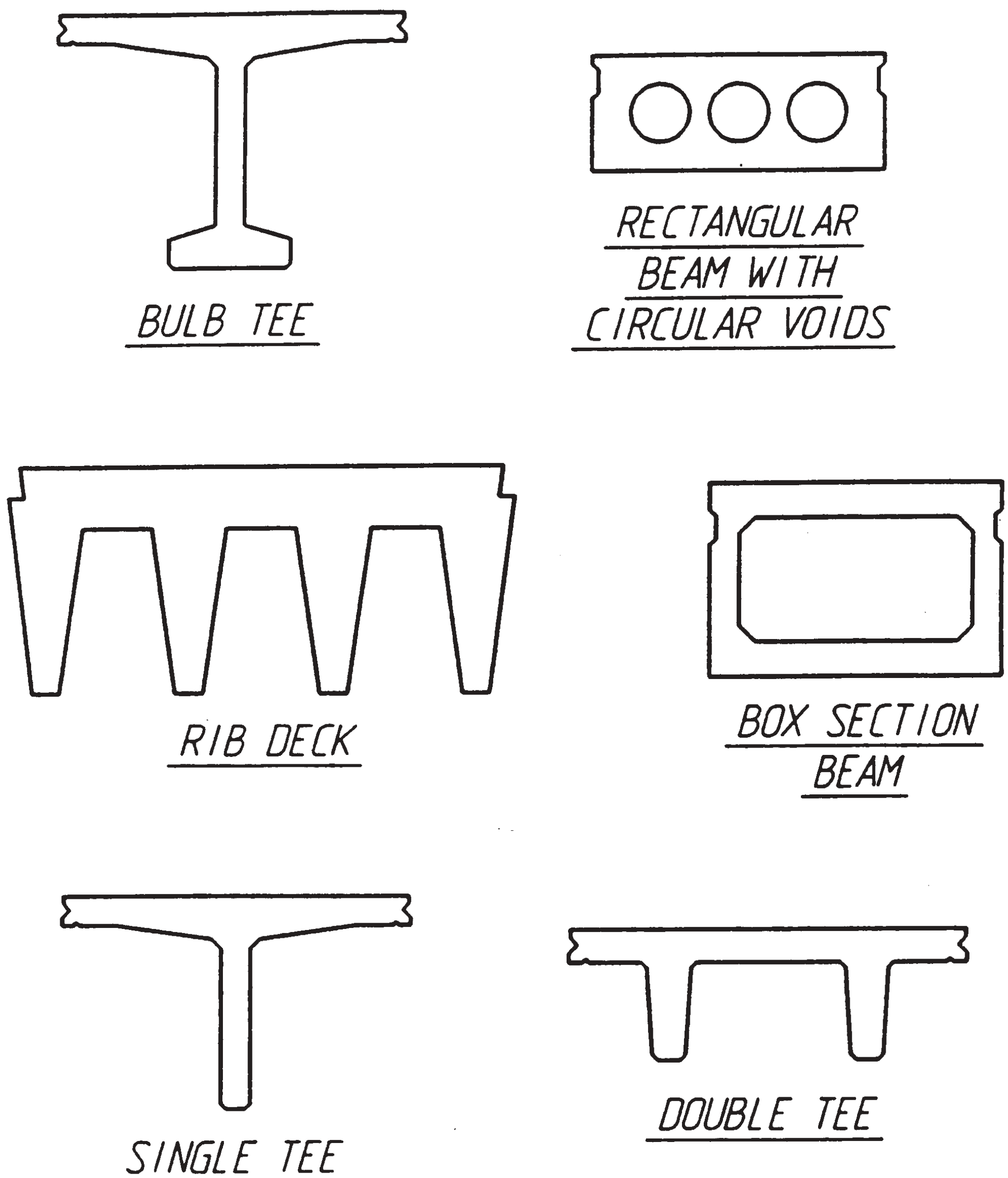


Fabricated Steel Girder


BULB TEE
RECTANGULAR BEAM WITH CIRCULAR VOIDS
RIB DECK
BOX SECTION BEAM
SINGLE TEE
DOUBLE TEE

Beam Types

Part 10

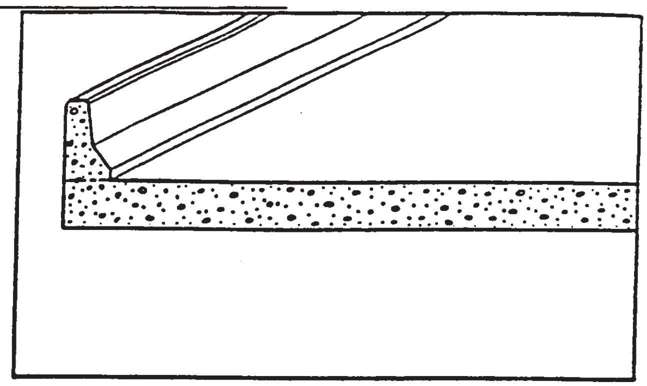
Cast-in-Place Girders

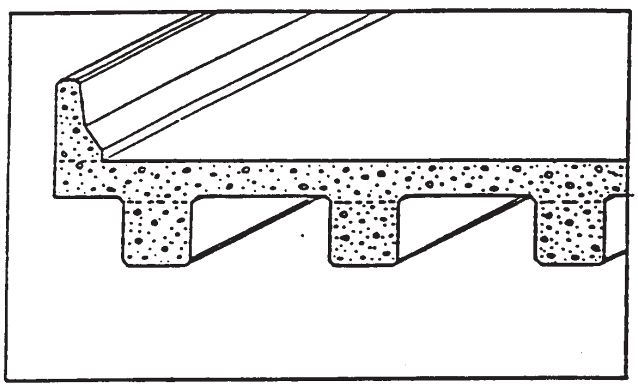
- **Types**

- **Key Processes**
  - *Falsework*
  - *Bottom Slab*
  - *Box Girder Stems/Webs*
  - *Deck Construction*
  - *Post-Tensioning*
  - *After Post-Tensioning*

Part 10 Cast-in-Place Girders

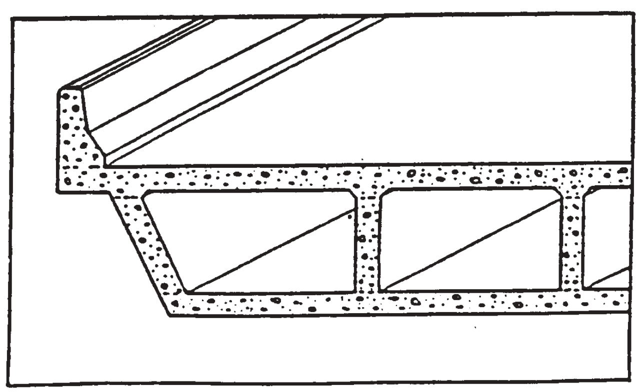
- Flat-Slab
  (only for spans
  less than 30 ft.)





- T-Beam
  (30-60 ft. spans;
  not very common)

- Box Girder
  (most typical
  & representative)



Types of Bridges

Key Processes

Falsework

Since virtually the entire superstructure of a concrete box girder bridge is cast-in-place, extensive falsework is needed to support each span until it can support itself. All falsework used will be in accordance with the contractor's approved falsework plans.

Falsework foundations:

- Falsework piling is usually required particularly if permanent piles are required for the structure.

  Falsework piling shall be spaced and driven in accordance with the approved falsework plans and *Standard Specifications*.

  Bearing capacity of falsework piling shall be as determined in accordance with Section 6-05.3(12) of the *Standard Specifications* or by load test to twice the falsework design load. The procedure for this loading shall be approved by the engineer.

- Mudsills may be used subject to the approval of the engineer provided the soil will:

  Sustain twice the falsework design load.

  Mudsill settlement will not exceed 1/4 inch settlement during the time it is loaded.

Support system:

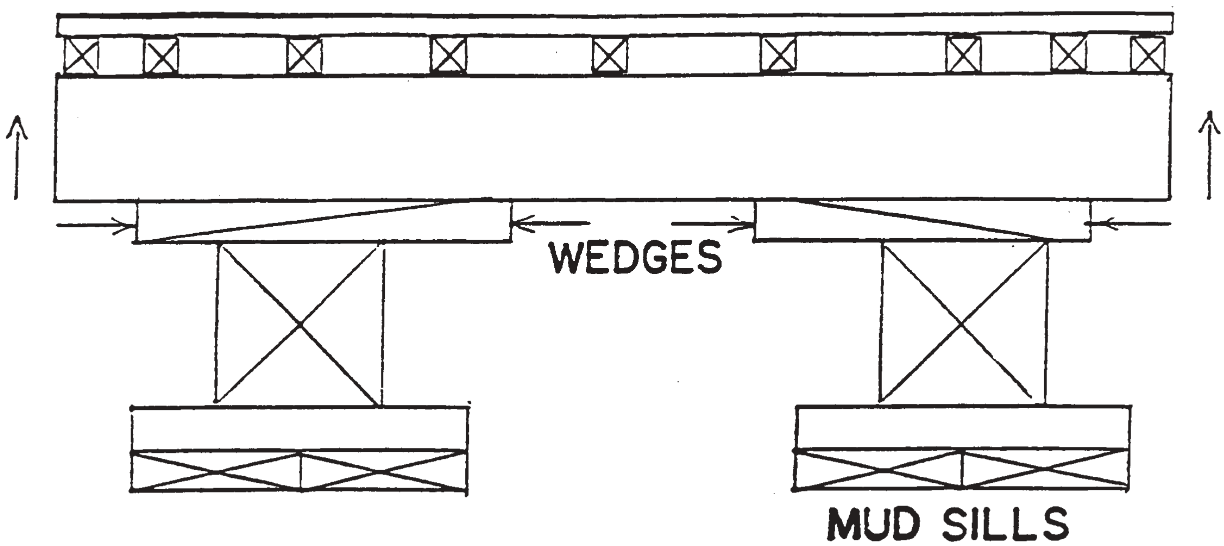
- Rigid vertical posts and diagonal braces (as shown in falsework).
- Secure fasteners.

Grade-adjusting devices:

- Wood wedges. Good quality, used in pairs with only one additional block allowed. Toe nail after adjustment.
- Screw jacks. Vertical.
- Properly adjusted to specified grade with uniform bearing.

Settlement of falsework to be shown in plans:

- Not to exceed 1 inch.
- No deviations to exceed (±) 3/8 inch or stop pouring.
- Uniform settlement for each tower leg > 30 kips.



Wood Wedges for Falsework Adjustment

Manufactured devices:

- I.e., friction collars, brackets, sand jacks, clamps, etc.
- Must be tested and certified for load capacity and deflection by an independent testing lab.

  Test shall be conducted with the same materials as will be used on the project.

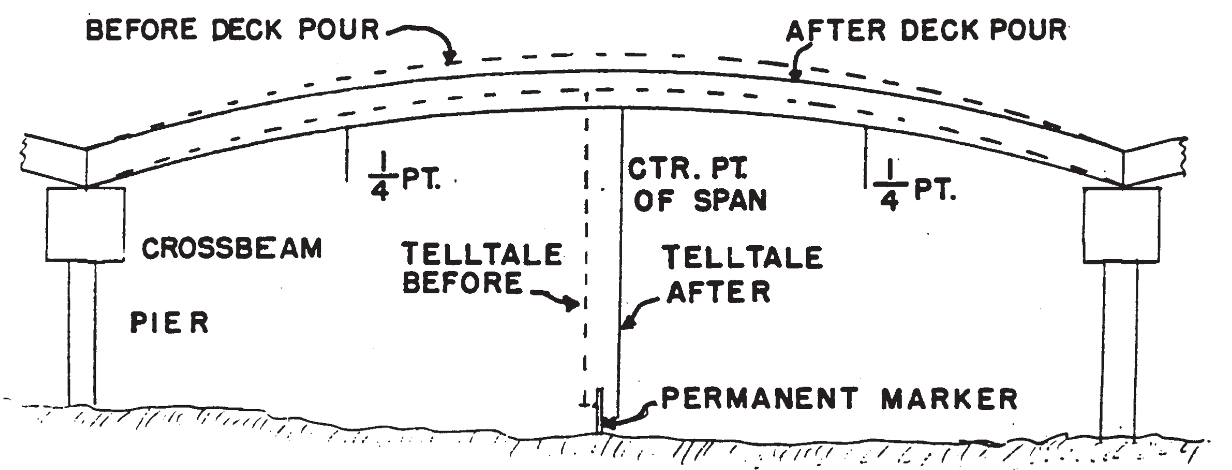
  Engineer shall be given the opportunity to witness such tests.

Stringers, Beams, and Joists:

- Shall be particularly rigid.
- Sizes and spacing shall be per approved falsework plans.
- The deflection shall not exceed 1/500 of the span under full load unless otherwise designated by the Engineer. An allowance for deflection shall be included in setting the falsework.

Tell-tales:

- Shall be placed at midpoints between the supports.
- The inspector shall use the tell-tales to check for settlement during and after superstructure pours.
- Adjust forms and reshore if settlement exceeds 3/8 inch.



Bottom Slab

Re-steel and stems layout often marked on bottom slab forms.

Check pier and abutment bearing areas — rigid construction joint or bearing pads and open joint materials.

Grade B or better plywood for bottom and side forms (exposed surfaces).

Check re-steel placement:

- Proper clearance and adequate support.
- Including vertical bars for stems.

Provision of drains 1½ inch for low points of post-tension ducts.

Construction joints at bottom of stems roughened or keyed per plans.

Box Girder Stems/Webs

Check side forms for correct batter.

Check end forms for:

- Block outs for post-tension ducts.
- 90 percent angle for P-T bearing plates.

Check P-T ducts (when applicable):

- Type, size, position per plans and shop drawings.
- Alignment and transition.
- Mortar-tight joints.
- No kinks, dents, or holes.
- Secure anchor ties.
- Drains at low points (open) and vents at high points (closed).
- Any conflicts between ducts and re-steel.
- Ends kept covered to avoid water or debris.

Re-steel (as for other structures).

Check interior forms for:

- Re-steel clearances and supports.
- Form ties to avoid P-T ducts.
- Drain holes, utility ducts' block-outs, bracket embedments, etc.

Check internal clearance of P-T ducts before concrete placement.

Concrete placement:

- Planned pour rate; avoid cold-joints; etc.
- Extra care around and under P-T ducts.

P-T ducts cleaned with oil-free compressed air to remove any mortar.

Deck Construction

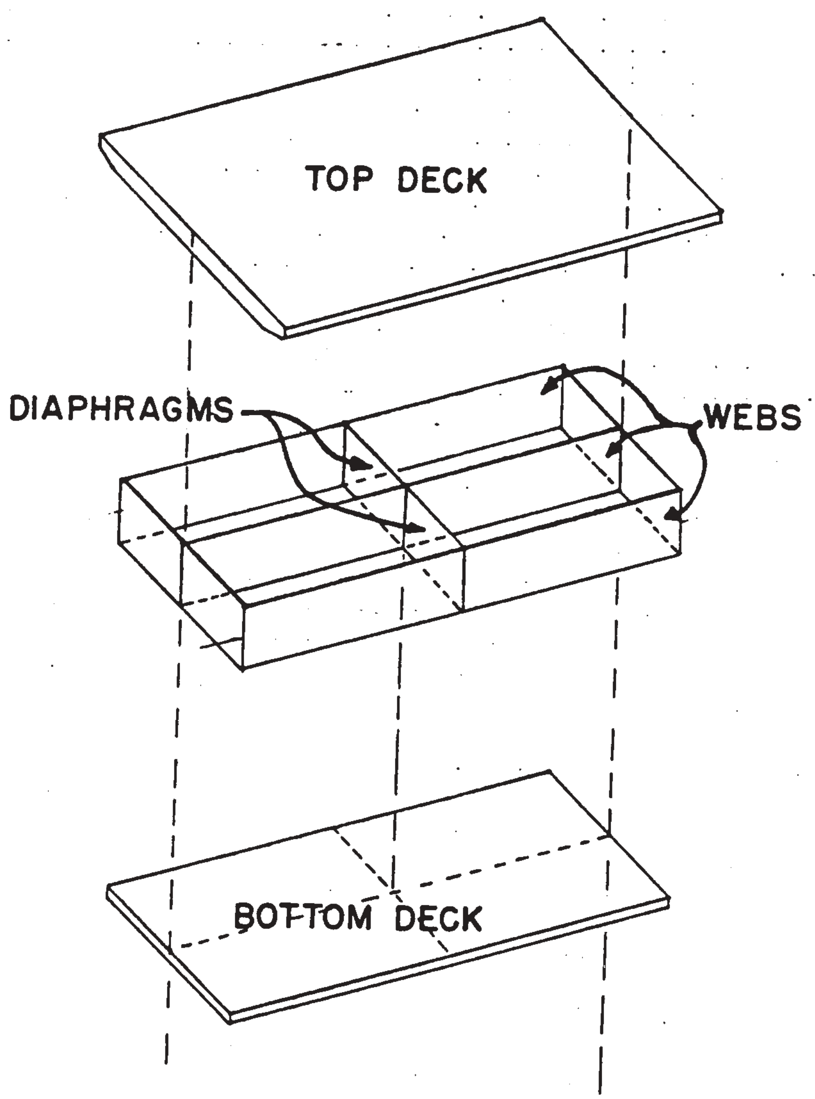
Preparations:

- Check for voids, cold joints, honeycomb, etc., as stems' forms stripped (particularly around and under P-T ducts).
- Contractor must demonstrate that P-T:

  Ducts unobstructed (if tendons not yet installed).

  Tendons free-moving.
- Good practice to pressure-test ducts to locate any leaks.

Deck pour and post-pour activities as for other types of bridges will be discussed later in Part 11.



Box Girder Assembly

Post-Tensioning

Installation of P-T tendons:

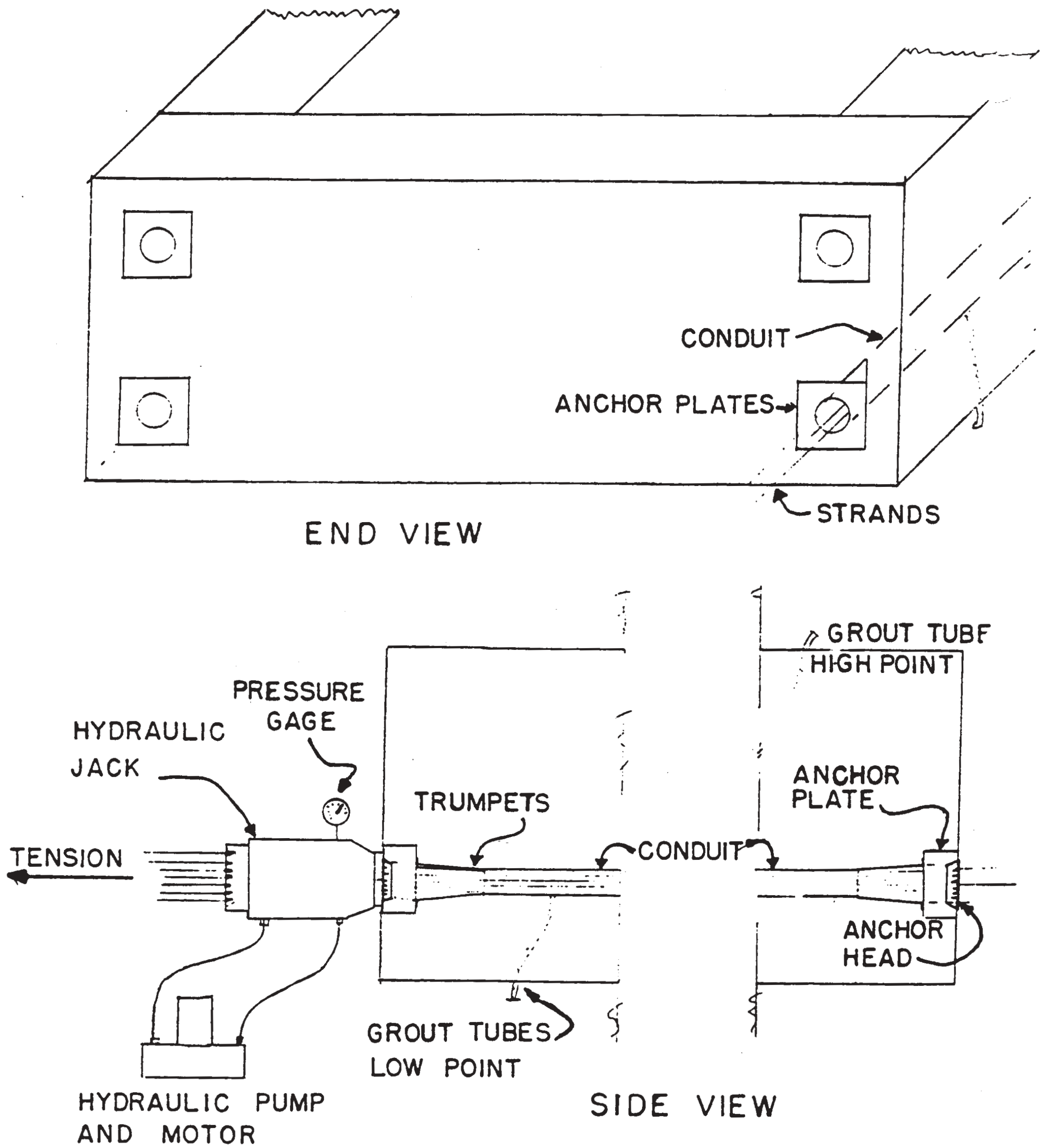
- Check condition, rust, dirt, etc.
- Check sizes, numbers of strands, etc., per plans and approved shop drawings.
- Contractor must demonstrate free movement, if previously installed.

Preparations for tensioning:

- Install tendon anchor plates and anchorages.
- Deck must reach comparable strength of at least 4,000 psi (or per plans).
- Remove side forms.
- Check certification of load-monitoring equipment to be used.

Tensioning operations:

- Per specified sequence.
- From one end (single-span); each end in succession (multi-span); or both ends simultaneously per plans.
- Avoid ends for safety.
- Initially to 20 percent of load (to remove slack) and mark for elongation measurement.
- To specified maximum load. Monitor loads and measure elongation.
- Check seating loss as transferred to anchors.
- Document loads, elongations, and seating losses.
- Cut tendons 1 inch from anchor plate (no torch).



Post-Tensioning

Preparations for Grouting:

- Clean with compressed air.
- Install caps and valves.
- Provide stand-by flushing equipment.
- Drains and vents closed.

Grouting operations:

- Check grout efflux time (11 to 20 seconds).
- Pressure-feed grout from low end.
- Waste at exit end until uniform flow (no slugs or water or air).
- Close exit valve.
- Bleed each vent (at high points).
- Must maintain presure between 100 and 200 psi for at least 10 seconds and close inlet.
- 50 to 75 for transverse deck tendons.

All caps, plugs, valves closed, and in place for at least 24 hours.

After Post-Tensioning

Can fill in post-tension block-outs, construct abutment back-walls; approach slabs, etc.

Remove falsework after all post-tensioning, but before barriers, walls, etc. Construct barrier walls, railings, curbs, etc.

- Suspended forms require removal plan.

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Part 11

Bridge Deck Construction

- **_Preparations for Deck Placement_**
  - *Class Exercise*
  - *Establishing Grade for Cast-in-Place (post tensioned)*
  - *Establishing Grade for Steel Girders*
  - *Forms and Falsework*
  - *Re-Steel Placement*
  - *Setting Deck Finishing Equipment*
  - *Checking Drum Clearances*

- **_Pre-pour Conference for Decks_**
  - *Concrete Pre-Placement*
  - *Concrete Placement*
  - *Finishing*
  - *Handwork*

- **_Completing the Superstructure_**
  - *Falsework and Forms Removal*
  - *Above-Deck Incidentals*
  - *Approach Slabs*

Part 11 *Bridge Deck Construction*

Preparations for Deck Placement

This section covers bridge deck construction in terms of:

- Preparation for deck placement.
- Placing deck concrete.
- Completion of the superstructure.

Before the concrete can be placed for a bridge deck, several preparatory activities must be performed, including:

- Establishing grades.
- Checking forms and falsework.
- Inspecting re-steel placement.
- Setting deck finishing equipment.

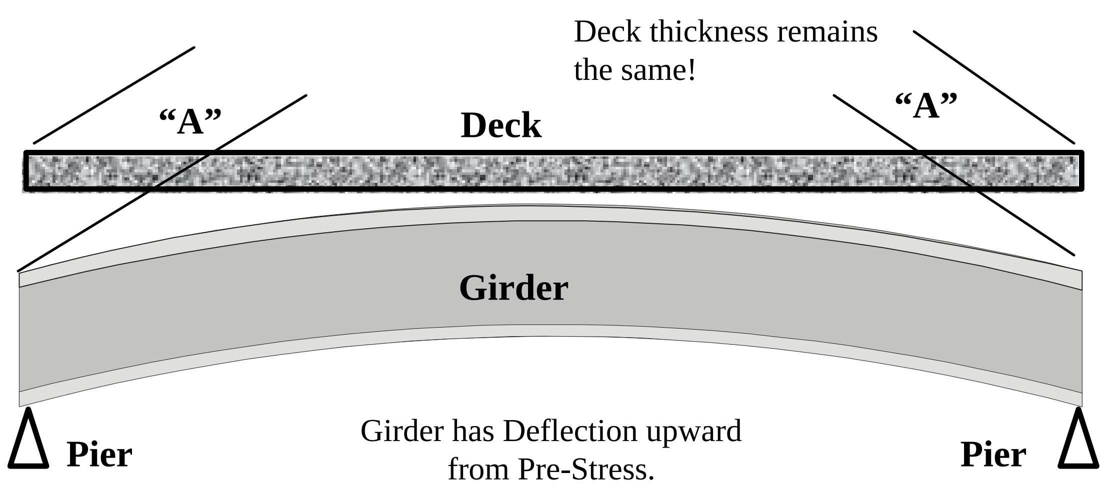
The department has a responsibility to establish grades to be used:

- As elevation references for deck construction.

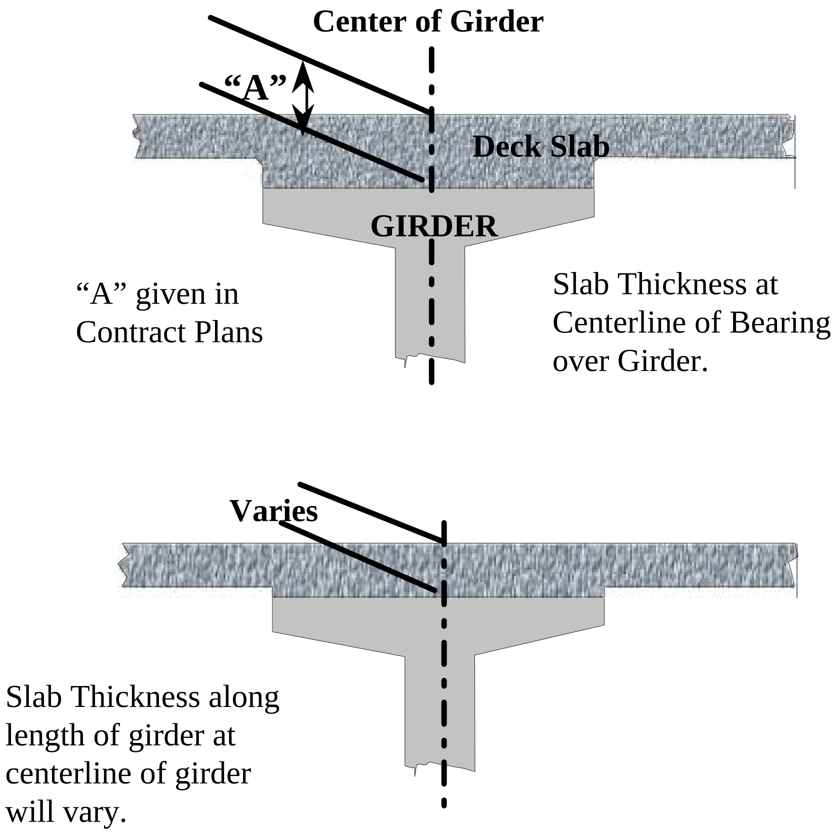
Establishing Grade for Pre-stressed Girders

It is suggested that the upward deflection of the girder be checked after placement and prior to forming. Compare the upward deflection at mid-span to the ends of the girder. This is to verify that the upward deflection of the girders top flange is not within the roadway deck.

"A" dimension shown in the contract plans is for making a smooth transition between girder and roadway deck. The "A" dimension only applies at centerline of the girder at centerline of bearing (Figures 11-1 and 11-2).



Pre-Stressed Girders
Figure 11-1



Pre-Stressed Girders
Figure 11-2

The "C" (Camber) dimension shown in the contract plans is taken at the mid-point of the girder. Camber is added to the deck grades to allow for anticipated downward girder deflection due to superimposed loads. The "C" dimension shown is used in determining the grade to set formwork and finishing machine grades (Figures 11-3 and 11-4).

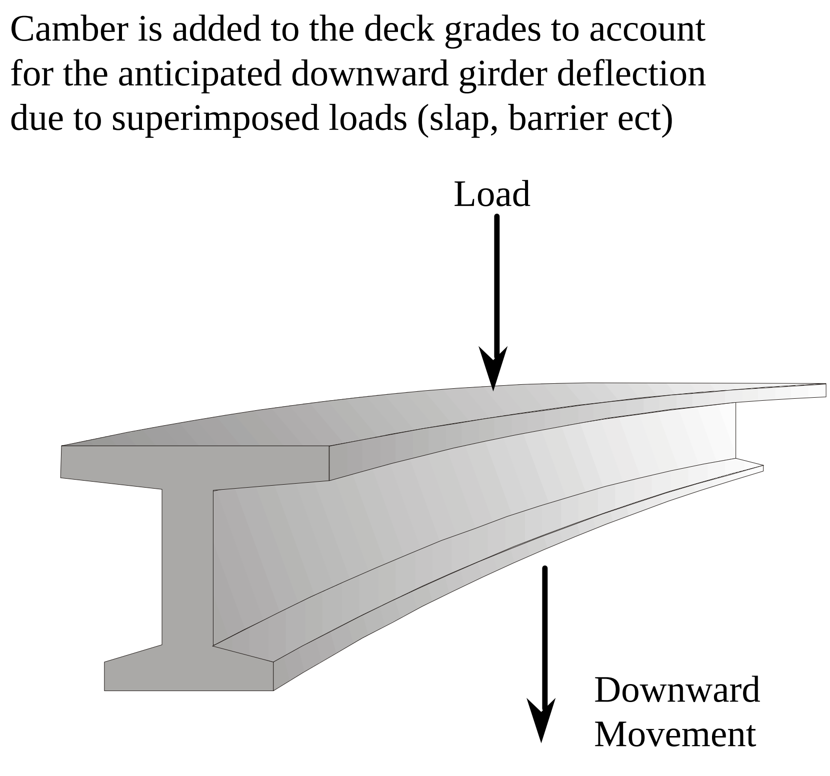
To determine the grade to set the formwork and finishing machine grades, use the equation:

$$Y = C - 4C(M - 0.5)^2$$

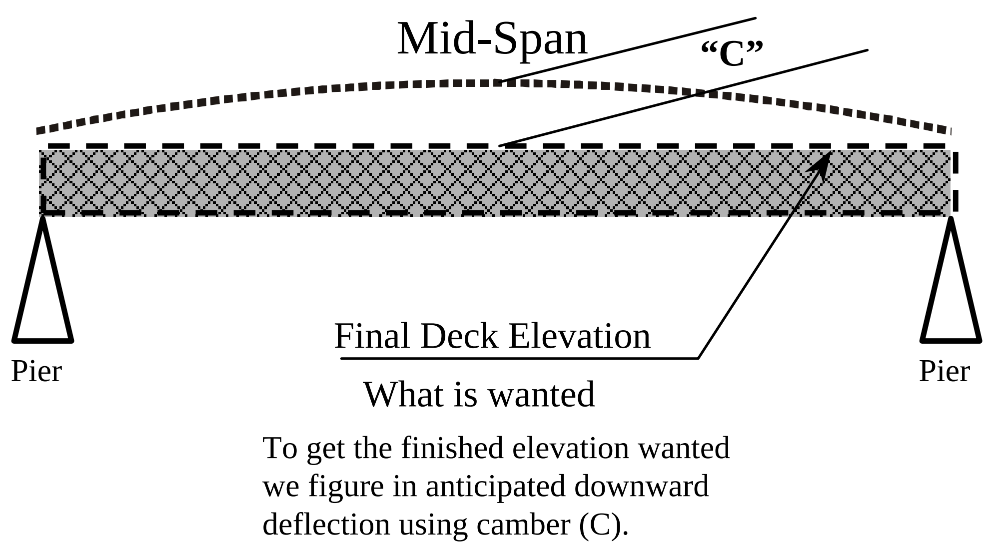
Y = Camber at any point along the span length
C = deflection due to superimposed dead load at mid-point
M = location of span in decimal percent

The calculated "Y" is added to the finished deck grades and is used to set formwork and rails for finish machine (Figures 11-5 and 11-6).

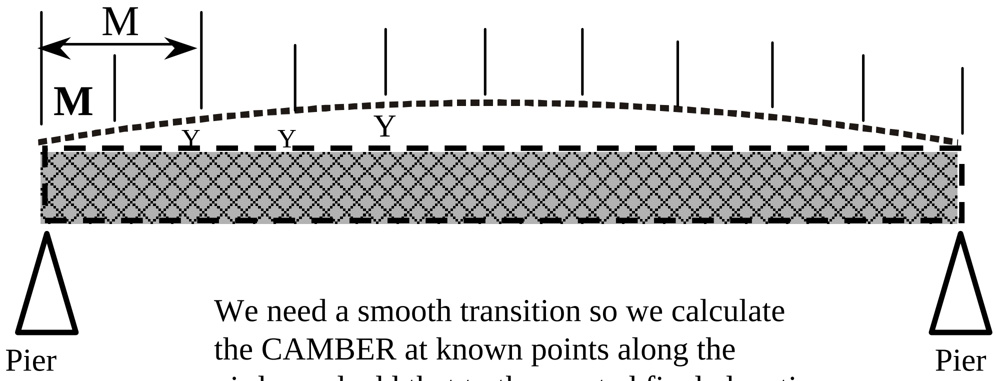
The up or down measurements are then set on the rebar or top flange of girder for reference.



Pre-Stressed Girders Camber (“C”)
Figure 11-3



Pre-Stressed Girders Camber (“C”)
Figure 11-4

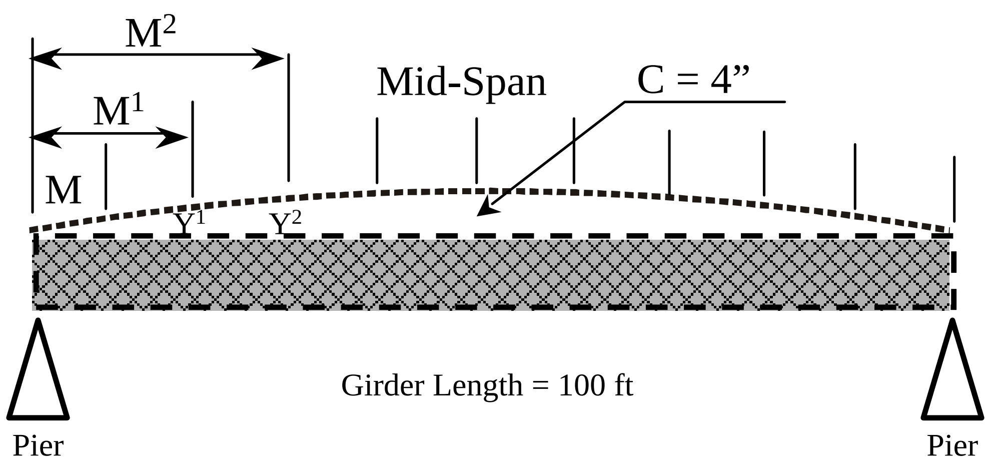


We need a smooth transition so we calculate the CAMBER at known points along the girder and add that to the wanted final elevation.

$$Y = C - 4C\,(M - 0.5)^2$$

Pre-Stressed Girder Camber
Figure 11-5

Example



Girder Length = 100 ft

M = 10’ 10 / 100 = .10
M^1 = 20’ 20 / 100 = .20
M^2 = 30’ 30 / 100 = .30

$Y = 4 - 4\,(4)\ (.10 - .50)^2 = 1.44” / 12 = 0.12”$
$Y^1 = 4 - 4(4)\ (.20 - .50)^2 = 2.56” / 12 = 0.21”$
$Y^2 = 4 - 4(4)\ (.30 - .50)^2 = 3.36” / 12 = 0.28”$

Take the calculated “Y” and add to the proposed finished deck elevation at the known station. As an example at M^1 the finished deeck elevation is 350.00 you would add 2.56” or 0.21 to 350.00 which equals 350.21.

Pre-Stressed Girder Camber
Figure 11-6

Class Exercise

Determine the camber and elevation needed to set the finishing machine from the following information:

Girder length = 102.7 C= 1”
Finish Deck Elevation at the 1/10 point = 100.21
Finish Deck Elevation at the 2/10 point = 100.32
Finish Deck Elevation at the 3/10 point = 100.45

Camber equation: $Y = C – [4C (M – 0.5)^2]$

1/10 = ______________________________

____

2/10 = ______________________________

____

3/10 = ______________________________

____

Establishing Grade for Cast-in-Place (post tensioned)

Camber is also used in the determining the grades for formwork and the finishing machine (see Pre-stressed girder for camber calculations).

Crush is added to the camber calculations. The anticipated amount of crush can be found in the contractor’s approved formwork plan.

Establishing Grade for Steel Girders

Profile each girder after placement

Forms set uniformly in relation to girder

Profile elevations used later to set screed rails, with allowance for anticipated deflection.

Forms and Falsework

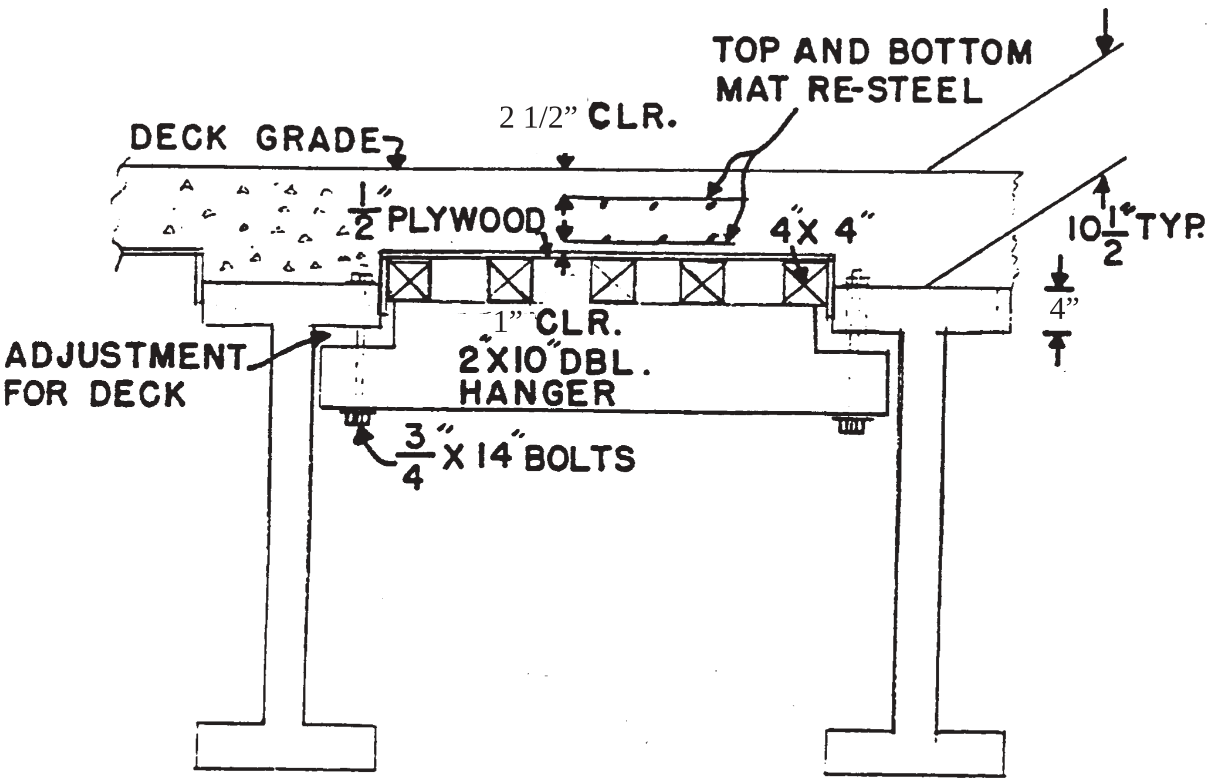
As for crossbeams or any other elements that require falsework, see that the falsework for the bridge deck is properly constructed:

- In accordance with approved forming plans.

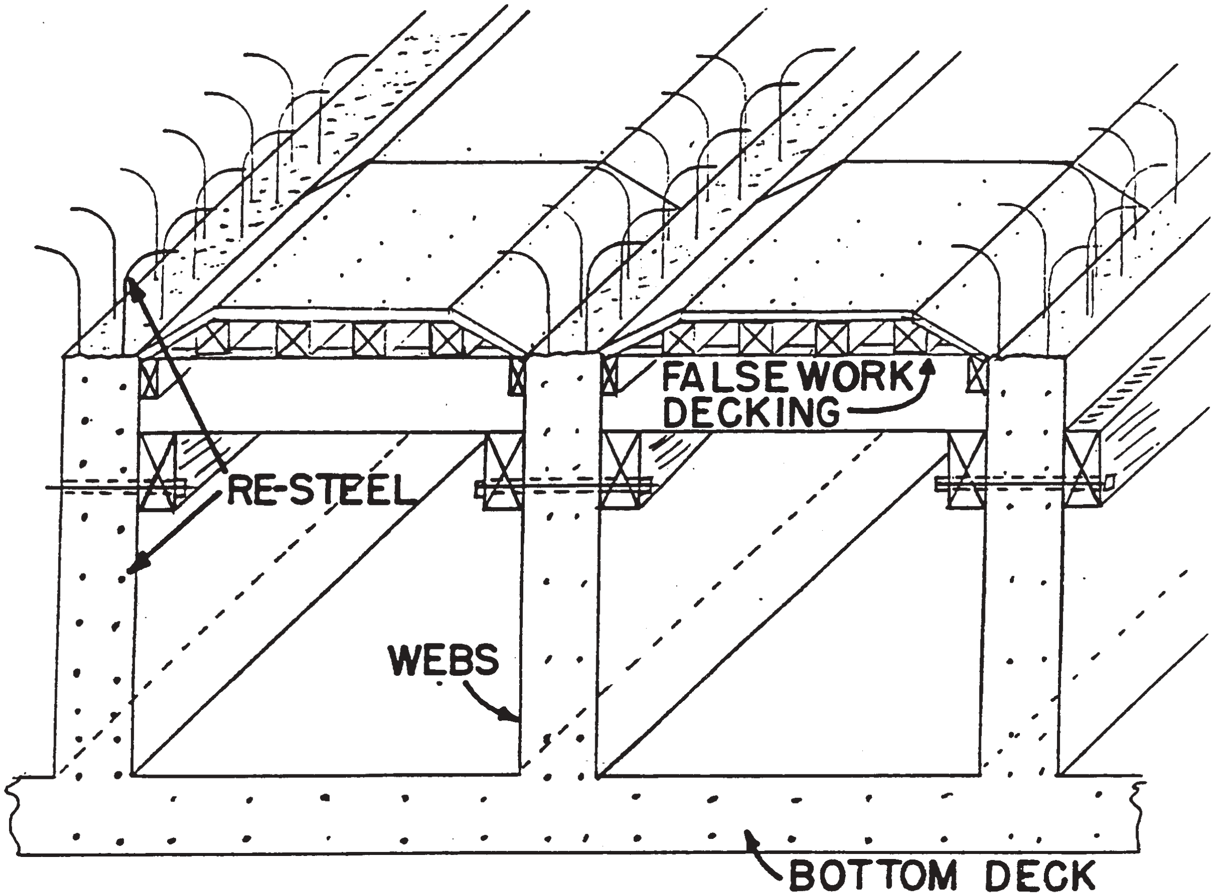
Some general items for inspection are for prefabricated girder.

Typically:

- An adjustable hanger between girders.
- Angle braces for cantilevered exterior portion.
- Cross-bracing between exterior and adjacent girders to prevent twisting.



Deck Falsework for Girder Type Bridges



Box Girder Deck Falsework

For cast-in-place box girders:

- Deck form supports:

  On stems as near as possible to top.

  Not on bottom slab.

- If permanent access:

  Provided. Forms must be removed after deck construction.

  Not provided. Cells cleaned out before forming.

Re-Steel Placement

In a typical-bridge deck, the key elements of the reinforcing steel include the stirrup extensions from the tops of the webs or girders. Two layers of deck steel, and the embedded portions of the steel for such above-deck incidentals as curbs and traffic barriers. You should inspect all of this re-steel for:

- Sizes, shapes, lengths, etc., as for other reinforced concrete.
- Properly positioned and secured in relation in girder rebar stirrups and shear connectors.
- Bottom mat supports at every:

  3 feet or less, if No. 4 bars.

  4 feet or less, if No. 5 or larger bars.

- Top mat supports as-needed to be rigid.
- Epoxy-coated re-steel:

  For top mat and parts of barriers.

  Nonmetallic or padded straps and slings to avoid damage.

  √ Approved patching material for any significant damage to coating.

Coated wire ties and metal chairs.

Setting Deck Finishing Equipment

The deck finishing equipment will ride on rails that are raised above the top surface of the deck. In most cases the rail will be outside the deck area but with wider decks the railing may be set with in the deck. If the railing is set with in the deck area the saddle supports need to be removable so that at least 2 inches of cover is obtain above the support.

As the screed rails and supports are roughed in, see that:

- They are aligned outside area to be finished.
- The saddle supports are:
  - Adjustable to different heights.
  - Securely set.
  - Closely set to avoid deflection in rail.
  - Removable to at least 2 inches if within deck limits (Figure 11-7).
- The rail and supports extend far enough beyond the end of the deck to provide all equipment with full access to the deck (Figure 11-8).

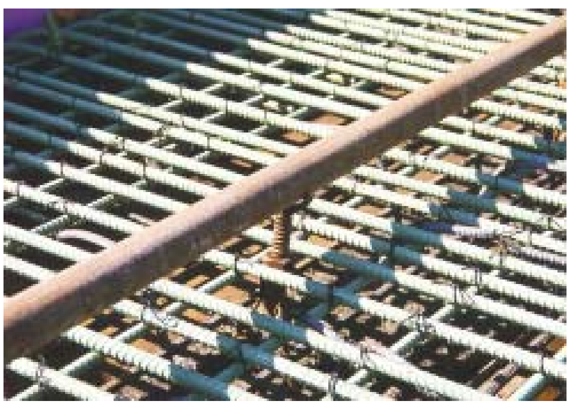


Figure 11-7

Saddle within deck limits. Saddle will be unscrewed leaving the base in place.

Figure 11-8

Rails extending beyond deck area.

After the rails are roughed in by the contractor, the deck finishing equipment must be placed on the rails so that the rails can be set to grade. The finishing machine must set close to the saddle that is being adjusted to grade (Figure 11-9).

Once the rail has been set to the final deck elevations then:

- String-line the boggie rails for drum carriage (Figure 11-10).
  - The rails can be adjusted to set a crown into the deck or have a flat surface.
- Raise or lower the support legs to obtain required elevation (Figure 11-11).

Figure 11-9

Legs of finishing machine are set over the saddles that are being adjusted to final deck elevation. It is important that the railing fits snugly into the saddle.

Figure 11-10

The drum carriage rides on this interior rail. The rail can be adjusted to place a flat or crowned cross slope. In this picture the rail is set for a crowned cross slope.

Figure 11-11

This is the adjusting leg for the finishing machine. The hand crank at top raises and lowers the machine to obtain proper clearance above resteel and deck depth. After setting the legs insert the keeper pin to hold the leg at the correct location.

Checking Drum Clearances

After the screed rails and finishing machine are set to the proper grade, you must thoroughly check the clearances of the finishing machine at various locations. To check the clearances the contractor shall do a dry run of the finishing machine over the entire length and width of the deck.

The inspector must verify:

- That the drum of the finishing machine can clear all bulkheads (Figure 11-12).
- That the proper deck depth will be achieved.
  - Do this by measuring from the bottom of the drums to the bottom forms.
- That there is the proper amount to concrete cover over the top resteel.
  - Do this by measuring from the bottom of drums to top of top resteel (Figure 11-13).
- Adjust forms as needed to correct for any deviations in deck thickness.
- Do NOT allow adjustments in machine crown or leg heights after clearances checked and approved.

Checking clearance between drum and bulkhead. Wood setting in and on resteel is being used to check deck thickness and clearance between drum and resteel.

Figure 11-12

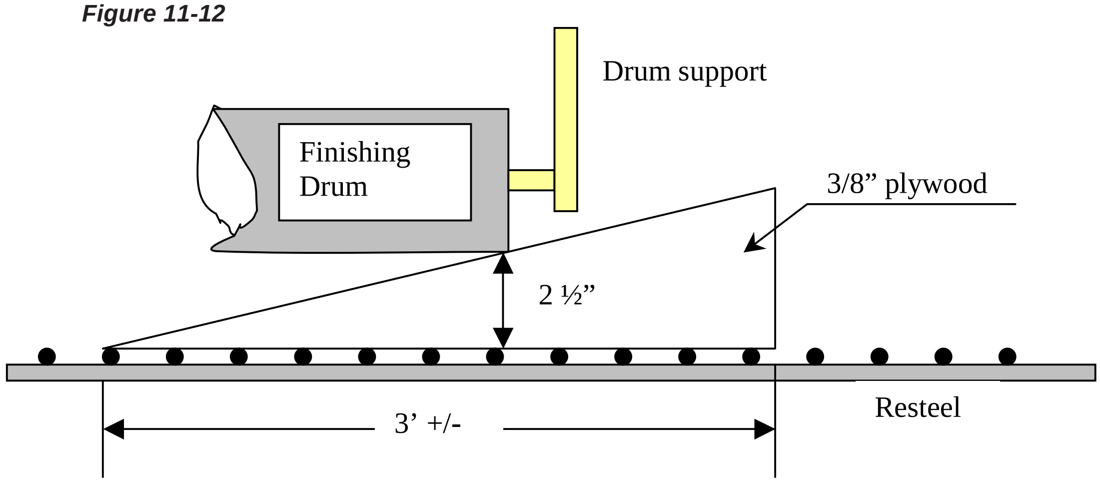


Figure 11-13
Top Deck Steel Clearance Template

Pre-pour Conference for Decks

A *pre-pour conference* should be conducted between the contractor and department personnel five to ten days prior to concrete placement. This conference should be held on the project to discuss the responsibilities and procedures of both parties during the actual deck pour. The following items should be discussed at this conference:

- Equipment to be used (contractors).
- Contractor personnel (ironworkers, carpenters, finishers).
- Number of and timing of mix trucks.
- Method of delivering mix to the deck (e.g., pump or bucket).

  Does contractor have backup system?
- Weather conditions.
- Traffic problems.
- Personnel responsible for state work.
- Concrete placement.

  Vibrating and finishing.
- Testing procedures.
- Texturing.
- Curing.

All of the above items should be thoroughly discussed and any problems solved well ahead of the day concrete placement is scheduled.

Typical deck concrete placement involves four basic types of operations:

- Placing and consolidating the mix.
- Mechanically finishing the deck to produce a uniform surface.
- Hand finishing areas that are not accessible to the finishing machine.
- Texturing and curing the deck.

Concrete Pre-Placement

Prior to placement the inspector should verify that the deck area is ready for concrete placement. The following items should be checked prior to giving approval to place concrete. These items should be taken care of prior to concrete arriving on the jobsite.

- Check the plans for any specified pour sequence.
- Forms have been cleaned.
  - All foreign material should be cleaned out of pour area such as:
    - Saw dust
    - Tie wire
- Standby equipment is on-site (*Standard Specifications* 6-02.3(6) and 6-02.3(11)).
- Cold weather protection on-site if required.
- Curing compound on-site with sufficient quantity.

Cleaning of the deck using compressed air. In confined areas a shop vac may have to be used. Foreign material that may contaminate concrete or be exposed when forms are removed needs to be removed prior to concrete placement.

Concrete Placement

The placement and consolidation of the concrete for a deck must generally meet the same requirements as for any cast-in-place structure. As for any other large pour see that the contractor provides adequate resources for the pour:

- Steady supply of concrete.
- Sufficient labor to work the concrete.
- See that the concrete is placed and consolidated across the full width of the deck in front of the finishing machine.
  - Do not allow the concrete to be moved by use of the vibrators.

Screeding

The primary purposes of the finishing machines are to strike off the excess concrete and produce a smooth, uniform deck surface. Monitor the operations closely to see that:

- The auger uniformly distributes the mix ahead of the drums.
- A slight roll of excess concrete is maintained in front of the drums but not so much that the drums ride up and over the excess (Figure 11-14 and 14A).
- The auger and screed assembly makes as many passes across the deck as needed to produce a uniform surface (without any ridges, streaks or other irregularities behind the finishing machine).
- Perform depth checks behind finishing machine to verify concrete depth and amount of cover over top resteel (Figure 11-15).
  - One way to do this is to take a piece of welding rod and bend one end. On the straight end place a piece of tape at the required deck thickness. On the bent end place a piece of tape at the required amount of cover needed. Use the bent end to find the top resteel.

Figure 11-14

Small amount of concrete in front of drums helps to fill in low areas. Inspector should make sure there is not to much nor to little.

Figure 11-14A

Too much concrete ahead of the rollers can cause the drums to lift up causing a high spot on the roadway deck.

Figure 11-15

After the concrete has been screeded off perform a depth check to verify thickness of concrete and amount of cover over top resteel.

Finishing

In addition to the Screeding equipment, the contractor must provide additional work bridges for such operations as:

Floating (Figure 11-16)

Floats at least 4 feet wide used in overlapping passes. Make sure that finishers do not over the work area. Over floating causes excess moisture to rise to the top of the concrete which can weaken the finish which leads to spalling.

Sometimes to help seal the surface the finishers will add water to the concrete surface. This is allowed but only as a fog spray (Figure 11-17) and not an excessive amount.

Figure 11-16

Finisher on work bridge using 4 foot float behind finishing machine.

Figure 11-17

Applying a fog spray on deck to help finishers to seal deck surface. If additional water is needed to achieve finish, a light mist is allowed.

Straight Edging (Figure 11-18)

Check the surface with a 10 foot straight edge both parallel and perpendicular to roadway centerline. Deck should be checked every 5 feet or less throughout deck length and width.

- Tolerance is $^1/_8$ inch in 10 feet.
- Contractor must correct any high or low areas.

Contractor using 10 foot straight edge to check deck surface for high and low areas. It is easier to correct when concrete is still pliable then to grind later.

Figure 11-18

Tine Texturing (Figure 11-19)

Texturing of the surface may not always be required. If the surface is not to be the final roadway surface and will be scarified for an overlay, then floating of the surface will only be required. Requirements for tinning are:

- $^1/_8$ inch wide by $^3/_{16}$ inch deep by $^1/_2$ spacing.
- Must not tear roadway surface.
- End 2 feet from curb line.

The tine marks should not overlap. Be sure concrete has not set to hard that the marks can not be placed at the proper depth or the concrete is too soft causing the tine marks to curl over.

Figure 11-19

Handwork

Some hand finishing is needed in areas that cannot be reached by the mechanical screeding equipment. Sidewalks and the areas around barrier wall and curb steel are common examples. In such areas, see that:

- The concrete is properly consolidated and rough-finished around barrier wall and curb re-steel to produce a good construction joint.
- Any sidewalks are uniformly floated and broom-finished as for other sidewalks.

If the rails for the screeding and finishing equipment are positioned within the width of the deck, you must also see that the handwork includes:

- Removing the rails and saddle supports behind the last work bridge.
- Filling any voids that result from removing the saddle supports.
- Consolidating, hand floating, and hand texturing the area so that it meets the same requirements as the rest of the deck.
- Curing compound:

  White-pigmented, if final traffic surface (clear, if not).

  In two applications perpendicular to each other.

  Total of 1 gal. per 150 sq. ft.

  Shield construction joints from compound.
- Covered with white sheeting:

  Weighted or taped at edges.

  Cured for at least 10 to 14 days depending on the type of concrete.

Curing (Figure 11-20)

Curing compound may not always be required. See *Standard Specification* 6-02.3(11) as to when a curing compound will or will not be required. Requirements for curing compound are;

- White pigmented, if final traffic surface (clear, if not).
- In two applications perpendicular to each other.
- Applied at a rate of 1 gallon per 150 square feet.
- Apply compound after bleed water has evaporated.
- Shield construction joints and exposed resteel.

Curing compound should be kept up close to operation to slow evaporation of moisture from concrete.

Figure 11-20

Completing Curing (Figure 11-21)

Must decks require both curing compound and wet cure but there are times when just curing compound or wet are required. Check *Standard Specification* 6-02.3(11) and your special provisions for requirements.

- Wet Cure for Deck
  - Wet quilted blankets or burlap continuously wet for required time.
  - Begin wet cure as soon as possible.
  - Covering with white reflective sheeting helps maintain moisture.
  - Make sure no runoff water enters into any surface waters such as lakes and streams.
- Curing Compound
  - After applying compound cover with white reflective sheeting.
  - Edges should be weighted down so to hold in place.

Placing burlap in water tank prior to placing on the deck will guarantee that moisture will immediately be on the surface. With new burlap the contractor may add dish washing detergent to tank water to help the burlap to adsorb water.

Figure 11-21

As soon as possible the wet blankets are to be placed onto the deck surface. Moisture must be maintained for the required cure time.

Completing the Superstructure

Once the deck is constructed, the superstructure must be completed by such activities as:

- Removing falsework and forms.
- Constructing above-deck incidentals.
- Constructing the approach slabs.
- Final check for smoothness.

Falsework and Forms Removal

As for any other cast-in-place part of the bridge, the falsework and forms can only be removed with the Engineer's approval. More specifically for post-tensioned, box girder bridges:

- Side forms must be removed before post-tensioning.
- Post-tensioning and grouting complete for at least 48 hours before bottom slab falsework removed.
- The remaining falsework may be removed after at least 10 days.

Above-Deck Incidentals

Above-deck incidentals include railings, barriers, curbs, etc. In most cases, these features can only be completed after the falsework has been released.

Approach Slabs

Approach slabs should be constructed where shown on the plans in accordance with standard plan A-2, but:

- Check bridge abutment compaction.
- Proper drainage.

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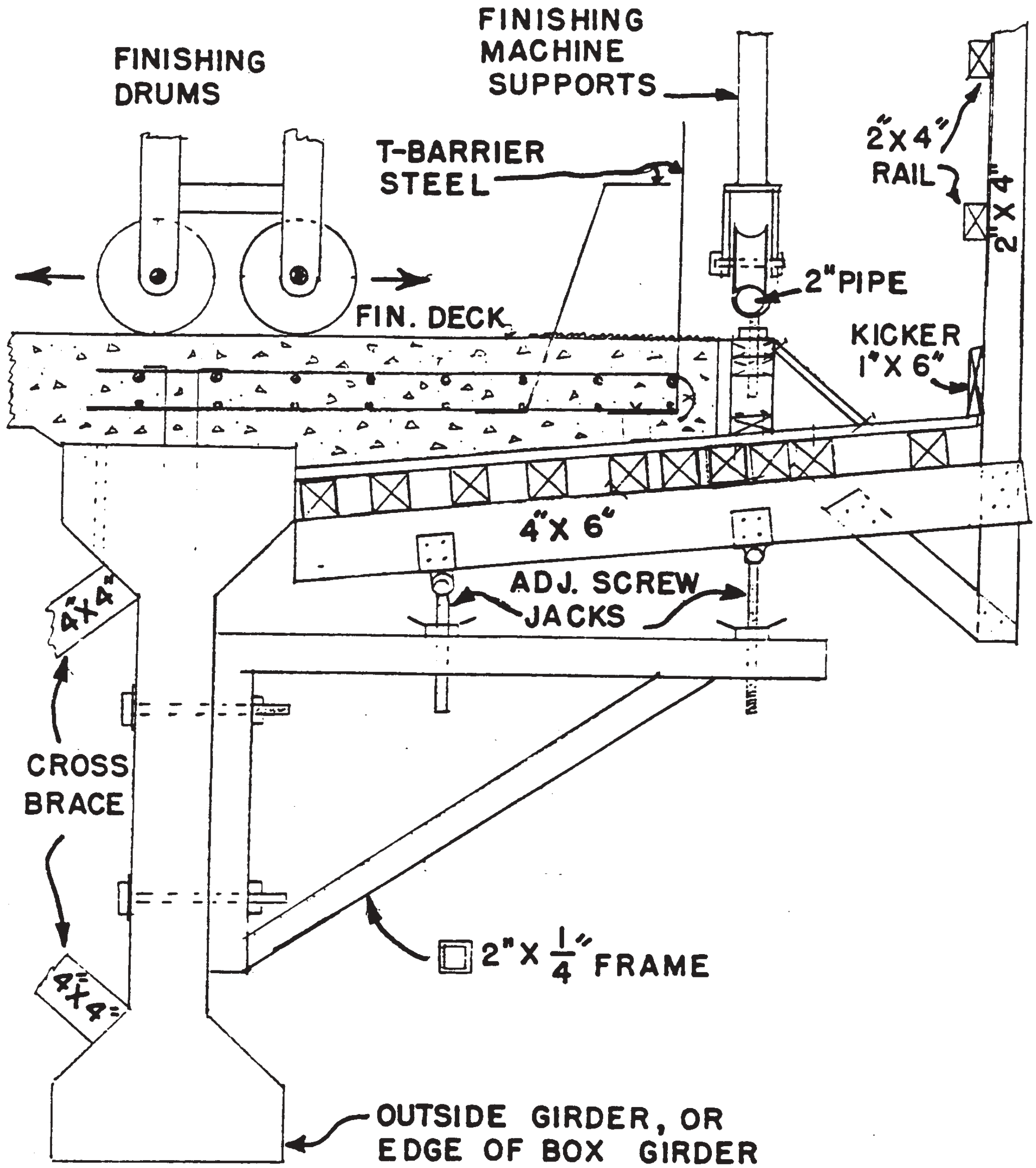
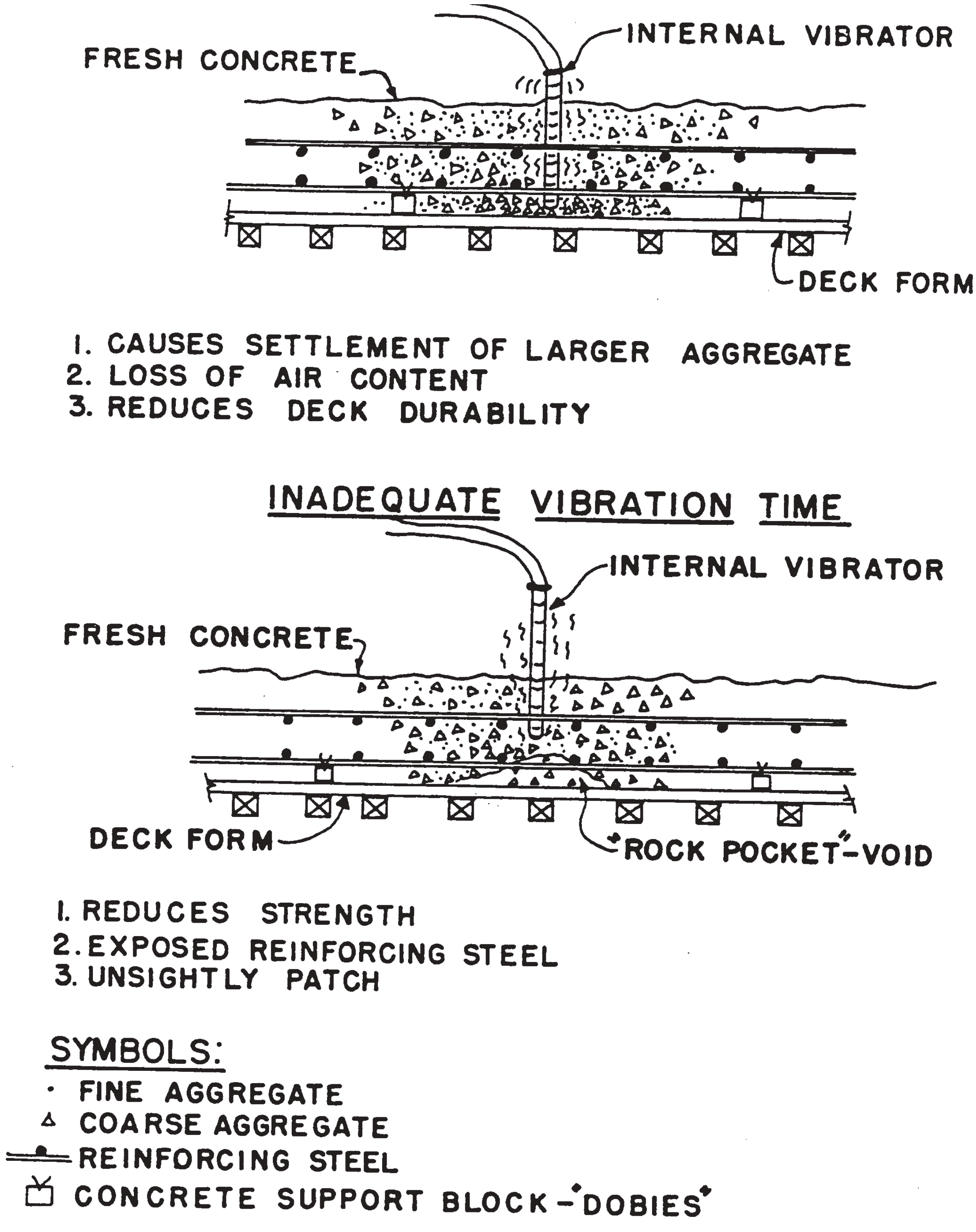
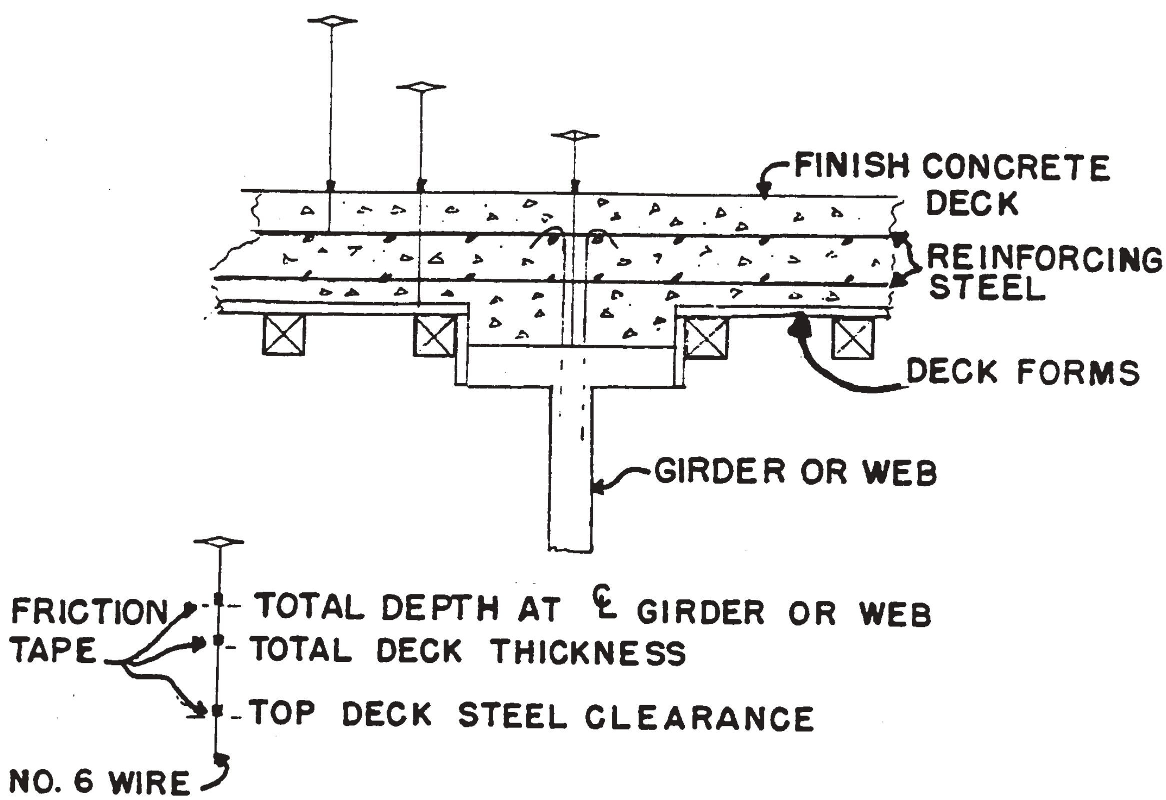


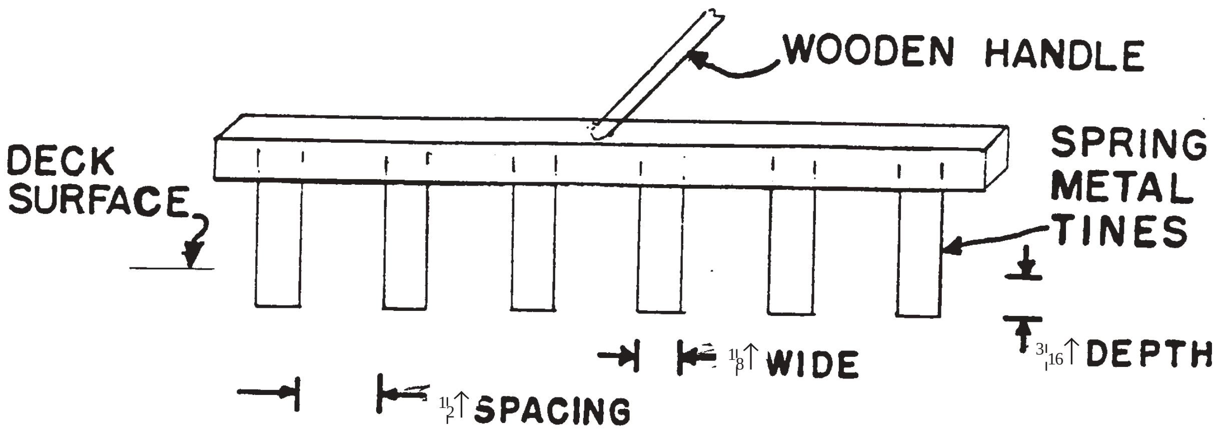
Falsework for Overhang



Excessive Vibration Time



Depth Gauge for Concrete Decks or Slabs



Texture Comb

Part 12

Bridge Deck Widening

- **Bridge Widening**
  - *Preparation for Construction*
  - *Construction*

- **Post Construction**

Bridge Widening

Widening an existing structure is no different then constructing a new structure except that a portion of the existing bridge will be demolished and you will be tying into existing resteel. The sequence of the construction also becomes important due to the fact that loading of the existing structure must be considered.

Preparation for Construction

Obtaining "As – Constructed" drawings prior to work will assist the inspector in knowing what to expect during demolition of the existing structure and the surrounding area. It is suggested they the inspector obtain "As – Constructed" drawings of:

- The existing structure
- Utilities
- Drainage

Prior to construction the inspector should do a field review. Some of the items that should be reviewed are:

- Existing grades, stationing and dimensions versus planned.
- Existing expansion joints openings versus planned openings.
- Existing fixtures such as luminaire locations.

Construction

Demolition plans must be submitted and approved prior to work commencing. The demolition plan should provide:

- Sequence of removal.
- Equipment:
  - Size – weight

    It is important that the weight of equipment is checked in the field if the equipment will be working on the existing structure. Point loading could become critical if existing structure is overloaded.
  - Type
  - Impact angle
- Falsework to contain debris.
- Make sure areas which are to be sawcut are not over fractured.

  The purpose of the sawcut is to give a straight vertical edge to place concrete against. The possibility to of concrete coming loose under traffic is greatly increased (Figure 12-1).

Contractor did not sawcut prior to demolishing the barrier but had to come in later and sawcut further back into existing deck to get vertical edge. The resteel shown will be straighten and tied into new deck steel.

Figure 12-1

- Be familiar with which resteel is to remain, which is to be removed and which can not be damaged.

  The resteel used for the widening will tie into some of the resteel of the existing structure. It is important to know what resteel needs to remain so loading can be transferred from bar to bar. It is also important to know what resteel can not be damaged by cutting.

  As an example sometimes resteel needs to be inserted into an existing column. This is can be done one of two ways. The contractor can use a roto-hammer or a core drill to drill a hole into the column. The roto-hammer will not cut through resteel, while a core drill can cut through the existing resteel lessening the structural integrity.

- Know what type of resteel splices (Figure 12-2) are required.
- Follow the construction sequence given in the plans unless otherwise approved.

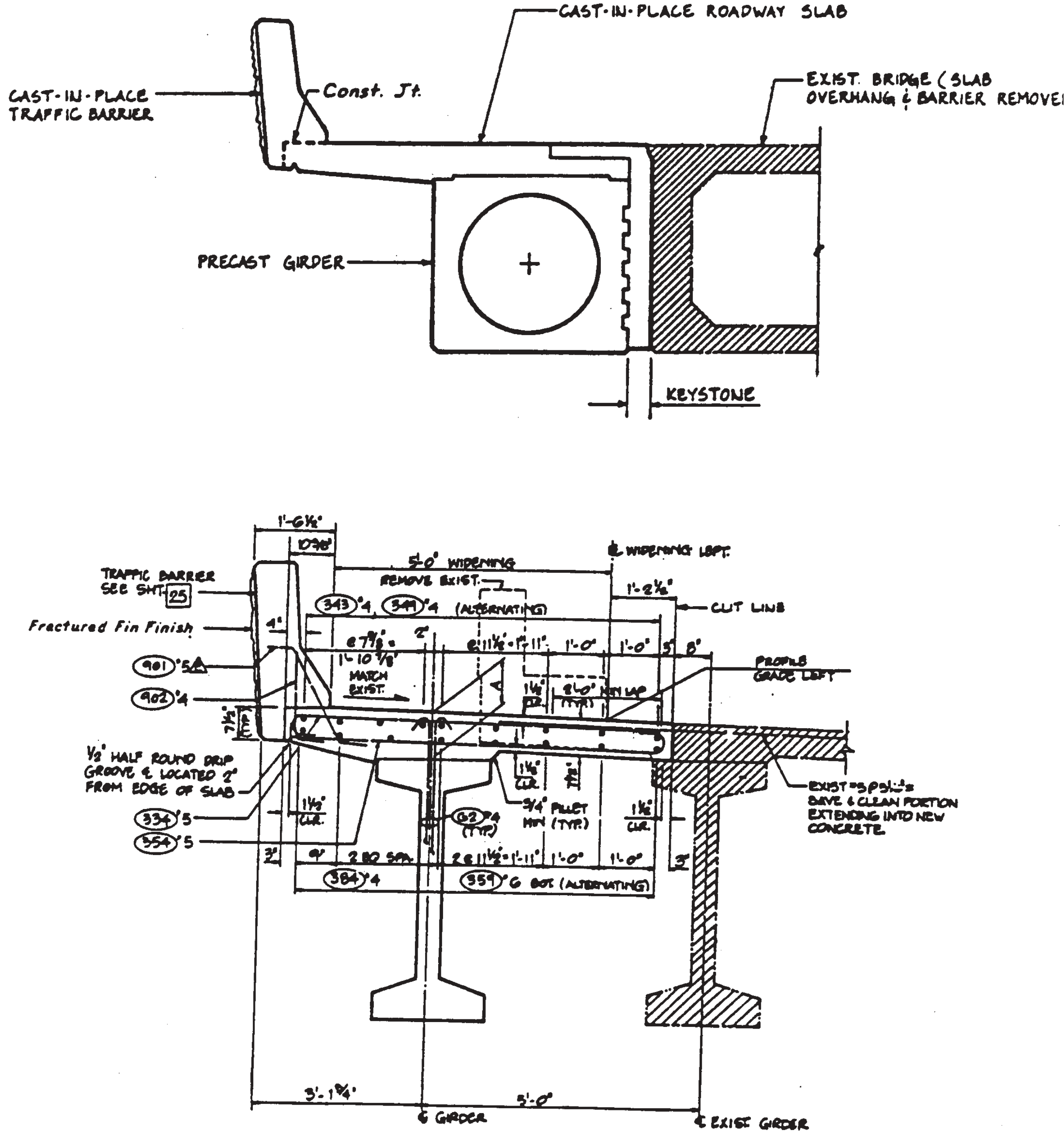
  Following the sequence of construction is important in respect to how the existing structure can be loaded. Sometimes the existing structure can not hold the additional loading that the widening could add. This is taken into consideration by doing pour-backs (Figure 12-2).

This is a pour back area between the new widening and the existing structure. Note that the resteel from the existing structure is tied to the new resteel by lap splices and the existing deck was cut back to a vertical edge.

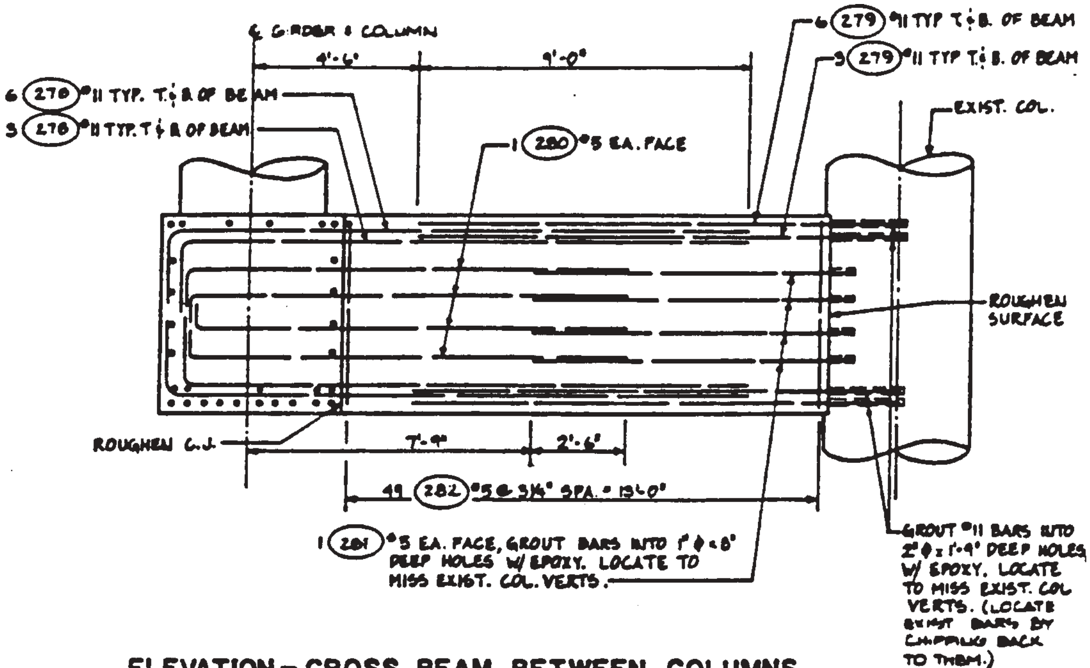
Figure 12-2

Post Construction

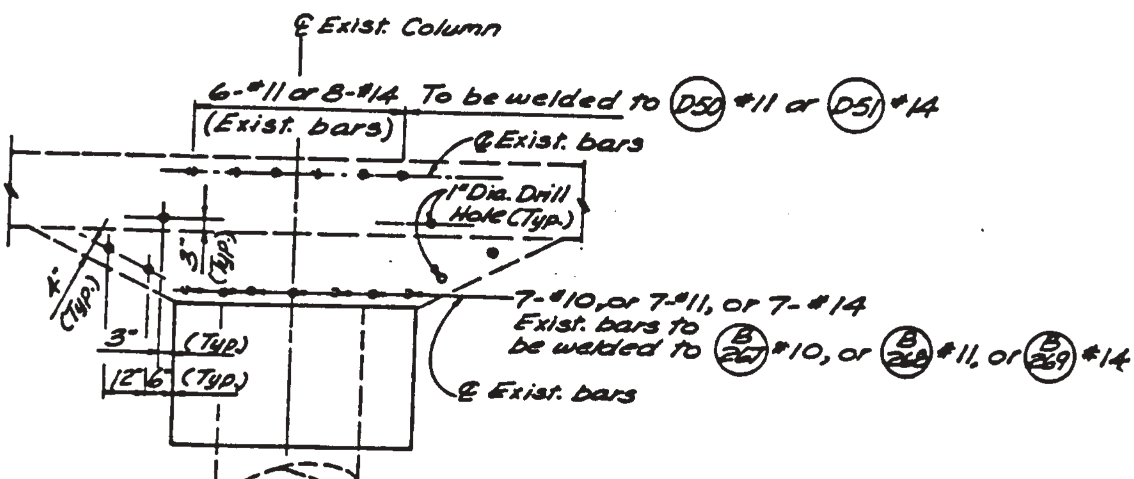
As soon as the bridge is completed, you must do the “As Constructed” drawings. These drawing are sent to Bridge Service Support.



Typical Sections



ELEVATION – CROSS BEAM BETWEEN COLUMNS



DOWEL AND WELD DETAIL (E)

Appendix A

Standard Specifications

- ***Standard Specifications for Materials Used on Structures***
- ***Standard Specifications for Structures***
- ***Minor Structures***

  Standard Plan and Construction Manual

Appendix A — *Standard Specifications*

Standard Specifications for Materials Used on Structures

Section	Division 9
9-01	Portland Cement
9-03	Aggregates for Portland Cement Concrete
9-04	Joint and Crack Sealing Materials
9-06	Structural Steel and Related Materials
9-07	Reinforcing Steel
9-10	Piling
9-19	Prestressed Concrete Girders
9-23	Concrete Curing Materials and Admixtures
9-24	Plastic Waterstop
9-25	Water
9-27	Epoxy Resins

Standard Specifications for Structures

Section	Division 6
6-01	General Requirement
6-02	Concrete Structures
6-03	Steel Structures
6-04	Timber Structures
6-05	Piling
6-06	Bridge Railings
6-07	Painting Structures

Construction Manual, Chapter 6 — Structures

Minor Structures
Standard Plan and Construction Manual

Section	
B-5, B-5a	Box Culverts
B-9	Headwalls
D-2, D-2g	Retaining Walls
G-2a, G-3a	Sign Foundations
J-8	Illumination Foundations
CM, 6-2.6 B	Slip Form Barrier
CM, 6-2.6 B	Traffic Barrier

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Appendix B

Inspector's Checklist

Appendix B *Inspector's Checklist*

Air-Entrained Concrete

I. Introduction

  A. Why Used

    1. Increase resistance to freezing and thawing
    2. Provide room for expansion and contraction
    3. Air bubbles found in the paste
    4. Bubbles separated throughout paste
    5. 300 billion bubbles per cubic yard at 4 to 6 percent air

II. Workability

  A. Lean and harsh mixes

    1. Reduce sand and water content
    2. Cohesive
    3. Reduces segregation and bleeding

III. Freeze-Thaw Resistance

  A. Expansion

    1. Entrainment voids act as a reservoir
    2. Pressure from freezing depends on the distance water has to travel to reach the void
    3. Spacing of voids is relative to tensile strength

IV. Resistance to De-Icers

  A. De-icing chemicals

    1. Cause sealing of surface
    2. Corrosion of reinforcing steel
    3. Counterosmotic pressure

  B. Calcium chloride

    1. Severe scaling

      a. 2 percent solution by weight for nonair-entrained

      b. 16 percent for air-entrained, 4 to 6 percent

  C. Sodium chloride

    1. 2 percent solution for nonair-entrained and air-entrained

D. Ammonium nitrate and ammonium sulfate
   1. Cause objectionable disintegration
   2. Prohibit use
E. Critical areas
   1. Direct application
   2. Dripping from underside of vehicles
   3. Poor drainage
   4. Ponding with de-icer solution
F. Curing
   1. Moist-curing at 70°F for seven days
   2. Recommended where de-icers are to be used excessively
   3. 14-day curing when 40°F temperature and Type I cement
   4. 7-day curing at 40°F with Type III cement
   5. 7-day curing at 40°F with Type I and II cement with accelerators
   6. Minimum of 30 days dry curing before de-icers are used
G. Protection from scaling
   1. Treat with linseed oil
   2. Neutral petroleum oil

V. Strength
   A. Relationship of properties
      1. Constant air content
      2. Strength varies inversely with w/c ratio
      3. Increase air may require more cement in richer mixes
      4. These are for leaner mixes 560 pounds cement per cubic yard
      5. Air- and nonair-entrained have greater demands for water as concrete temperature rises and same slump is to be maintained
   B. Abrasive resistance
      1. Strength is the most important factor
      2. When concrete strength increases so does abrasion resistance increase
   C. Watertightness
      1. Air-entrained and low w/c ratio

VI. Factors Affecting Air Content

- A. Coarse Aggregate
    1. Little change over 1½ inches size aggregate
    2. 1½ inches and smaller AE increases sharply as size decreases because of increased mortor volume
    3. As cement content increases, AE decreases
    4. Air void spacing decreases when cement content increases
    5. Cement fineness increases, AE decreases
    6. High alkali cements
        - a. Entrain more air
        - b. Watch when using different sources
    7. Entrapped air from mixing
- B. Fine aggregates
    1. Causes more air to be entrained for a given amount of AE cement or admixture
    2. No. 100 to No. 30 graduation entrain more air
    3. Appreciable amount of material passing the No. 100 sieve will result in reduction of AE
    4. Sources
    5. Shape and surface texture
    6. Organic materials

VII. Slump and Vibration

- A. Slump
    1. Water cement ratio
    2. Increases in slump to 6 inches increases air content
    3. W/c ratio affects air-void characteristics
        - a. Increases size of air bubbles
        - b. Air-void spacing
        - c. Both of these reduce durability
- B. Vibration of plastic concrete
    1. Five to 15 seconds for consolidation
    2. Greater the slump, greater the reduction of air
    3. Size of air voids reduced
    4. Spacing remains the same
    5. These are normal conditions

VIII. Concrete Temperature

A. Air entrainment

1. Less air is entrained as temperature of concrete increases
2. 41 to 77°F no appreciable change with 3-inch slump concrete
3. Using hot water
   a. Lose effectiveness during batching
   b. Added after temperature stabilizes
   c. Increased concrete temperature during mixing generally reduces air volume

B. Mixing

1. Type and condition of mixer
   a. Amount of concrete being mixed
   b. Worn mixing blades
   c. Harden concrete collection on drum/blades
   d. Stationary and transit mixers
   e. Overloaded and less than capacity
   f. Prolonged and excessive mixing
      (1) High slump, air increases
      (2) Low slump, air decreases along with slump
      (3) Principal effect is reduction in slump

Concrete Structures Inspector's Checklist

1. Location of concrete placement _______________ Contract # ____________
   (span, pier, station) Structure ________–_____
2. Part of structure to be poured _________________ Inspector _____________
   (seal, ftg. deck, etc.) Date_______________
3. Pour scheduled for __________ (a.m.) (p.m.) on ________________________
   (time) (day of week and date)

   A. Weather forecast is: ____
4. Foundation

   A. Excavation to correct elevation if pour is against ground

   B. Foundation excavation material encountered is same as boring logs and has been approved by the Project Engineer

   C. Moisture test excavated materials when reused for backfill

   D. Piling complete and accepted

   E. Pile cutoffs treated if required

5 . Forms (Substructure and Superstructure)

A. Constructed per approved form drawings

B. Pour rate specified at _______ ft./hour @ __________ °F

C. Longitudinal alignment checked

D. Transverse form alignment checked

E. Dimensions verified

F. Elevations checked

G. Plumb or batter verified

H. Form material of proper thickness and facing and in satisfactory condition

I. Forms coated with a release agent

J. Studs and walers in accordance with approved plans

K. Kickers and bracers in compliance with approved plans

L. SHE bolts, snap ties, bolts, nails, etc., in accordance with approved plans

M. Checked above for snug tight fit and **secured** with provision for checking of the same during the pour. SHE bolts tight — shoes tight and secured

6. Falsework

A. Constructed per approved F/W drawings

B. Mudsills have full bearing on 95 percent maximum density material

C. Full bearing on piles, pony-bents, pile caps, stringers, and joists

D. Falsework properly aligned per approved plans

E. Braces, girts, and struts per approved plans

F. Tattletails set

7. Reinforcing Steel

A. Reinforcing steel will be accepted by Mill Test Reports accompanied by Fabricator's Certification. Coated rebar should be tagged and signed by WSDOT Inspector

B. Welds completed and checked; welder certified

C. Rebar checked in the forms as indicated below:

(1) Lengths and splices correct

(2) Form to rebar clearance checked (bottom, sides, and top)

(3) Sizes, spacing, number, epoxy, etc. checked

(4) Ties and rebar supports approved or as specified (Chairs correct height, booties, epoxy, etc.)

(5) Rebar tying into future pours have correct alignment and splice length

8. Concrete
    - A. Class of concrete __________________
    - B. Retarder _________________________
    - C. Water reducing admixture
    - D. High range water reducing admixture
    - E. Air entraining additive
    - F. Concrete quantity is _____________________ cubic yards (est./calc.)
9. Miscellaneous
    - A. Anchor bolts graded, aligned, etc.
    - B. Expansion dams assembled, painted, graded, bolted, aligned, etc.
    - C. Concreted in-place items installed (conduit, inserts, bolts, etc.)
    - D. Luminaire blockouts in place
10. Method of Placing Concrete is:
    - A. Pump
    - B. Pump back-up system available
    - C. Bucket; two per crane for large concrete placement
    - D. Chute
    - E. Tremie
    - F. Other
11. Construction Joints
    - A. Approved location
    - B. Shear keys fabricated to plan size for use where required
    - C. Elevations for construction joints set and checked
    - D. Construction joint bulkhead properly formed, braced, and aligned
    - E. Open joints formed and … dummy joints formed where shown on plans
    - F. Premolded joint filler secured (galvanized nails $1\frac{1}{2}$ inch in conc.)
    - G. Joint against old concrete, surface is cleaned, roughened, and wetted, epoxied where required
    - H Pile cutoffs treated if required
    - I. Excavation to correct approved elevation if concrete placement is against original ground

12. Post Tensioning (Optional)
    - A. Ducts installed per approved profile and alignment
    - B. Ducts securely tied
    - C. Duct joints sealed
    - D. Check for holes or dents in ducts
    - E. Inlet/outlet and high/low grout vents installed and out of pour
    - F. Contractor prepared to run rabbit through ducts immediately after concrete placed; then seal ducts
    - G. Ducts clear and unobstructed
13. Finishing
    - A. Finish required for this concrete placement is _________________ and has been reviewed with the contractor
        - (1) Work bridge for finishers available
        - (2) Grout rod(s) as specified
        - (3) Screed rods set at correct elevations
    - B. Finishing machine to be used; review operating instructions
        - (1) Finish machine will clear bridge rail rebar
        - (2) Finish machine string lined (plane section, crowned, etc.)
        - (3) Augers set and in good condition
        - (4) Finish machine will clear all bulkheads
        - (5) Finishing machine screed rail graded and eyeballed
        - (6) Finish machine leg height checked and recorded (rear 1/8 inch higher than front)
        - (7) Dry run finishing machine (document rebar cover and deck thickness)
        - (8) Identify areas that adjustments and recheck
14. Curing
    - A. Reviewed specifications and contractor proposed method
    - B. Special equipment ready (sprayers, work bridges, mixers, etc.)
    - C. Liquid membrane-forming compounds are from an approved lot
    - D. Men assigned to have compound ready and adequate amount to do job
    - E. Water, cotton blankets, white polyethylene sheeting available, and a plan for maintaining the cure for the specified period
    - F. Work bridge available for applying cure
    - G. Cure premeasured for yield

   H. Cure agitated as recommenmded by manufacturer
   I. Cure pump applicator demonstrated; no thinner in curing compound
   J. Weather forecast for next seven days ____________________
   K. Cold or hot weather curing plan when recommended

15. Cleanup completed or is expected to be completed by _________________
   A. Falsework and form removal
   B. Backfilling foundations and wing walls
   C. Final grading for slopes and bridge protection

Properties of Concrete

Features	**Elements**
1. Workability	1. Cement
2. Finishable	2. Aggregates
3. Strong	3. Water
4. Durable	4. Additives
5. Watertight	5. Temperature
6. Wear Resistant	

Cold Weather (35°F and Lower)

1. 60°F minimum temperature in forms
2. 60 to 35°F protect forms, slow curing
3. 35 to 14°F special heat application
4. 14 to 0°F all curing ceases

Hot Weather (90°F Plus)

1. 90°F maximum mix temperature
2. Reduce heat of forms and re-steel
3. Check weather factors
   a. Wind velocity
   b. Relative humidity
   c. Temperature
4. Reduce transporting, placing, and finishing time
5. Apply cure method ASAP

Cold Weather Concreting

Plans should be made to protect the concrete with enclosures and windbreaks. Portable heaters, insulated forms, and blankets should be ready to maintain concrete temperature. Insides of forms, resteel, and embedments should be free of snow and ice. Thermometers should be installed to monitor temperature.

What Happens to Concrete When it Freezes?

1. Gains very little strength
2. Reduce degree of saturation by hydration
3. This point is reached at 500 psi compressive strength
4. Below 14°F cement hydration or concrete strength gain ceases; Up to 50 percent reduction in strength if freezing occurs within 24 hours
5. Heat is created by the reaction of water with cement initially
6. Low slump helpful in minimizing cold weather concreting

Effects of Freezing Fresh Concrete

1. Gains very little strength
2. No flooding or sprinkling
3. Degree of saturation is reduced when concrete attains 500 psi
4. Concrete frozen once can be restored if favorable cure conditions are provided
   a. Not as resistant to weathering
   b. Not as water tight
5. Air-entrained concrete not as susceptible to damage by early freezing

Concrete Strength at Low Temperature

1. Low temperature reduces rate of hydration
2. Above 14°F it will gain strength slowly
3. Below 14°F it stops gaining strength

Heat of Hydration

1. Caused by cement reacting with water
2. Heat generation caused by dimensions, ambient air, w/c ratio, cement composition, amount, and admixtures
3. Finishing usually accomplished during hydration time

Special Concrete Mixes

1. More cement lower w/c ratio (low slump)
2. **No** antifreeze solution added
3. Type III cements

4. 2 percent calcium chlorides. Not used in structured concrete
5. Air-entrainment should be used during cold weather

Concrete Temperature During Mixing

1. Concrete at lower temperature for massive pours
2. Heat lost during transporting and placing
3. Fresh concrete should be at 70°F for cold conditions
4. Higher than 70°F causes thermal shrinkage
    a. Requires more water
    b. Plastic-shrinkage cracking (moisture loss through evaporation)

Aggregate Temperature

1. Aggregate must be thawed before mixing
2. Below freezing, only fine aggregates need to be heated
3. Steam heat aggregate piles (35 to 125 psi steam pressures)

Control Test

1. Temperature control using the thermometer
2. Thermometer installed in concrete
3. Laboratory control test cylinder
    a. Maintained at 60 to 80°F at job site
4. Field cured test cylinders
    a. Cured under the same conditions
    b. Molds stripped from cylinder after 24 hours
    c. Wrapped in plastic bag
    d. Maintain 60 to 80°F when transporting to lab

Placing Concrete on Cold or Frozen Ground

1. Advantage is more stable work area
2. Get off to early start and get above ground
3. Different procedures from upper level work
    a. Ground must be thawed
    b. Cement hydration will provide of the heat
    c. Construction of enclosures much simpler (indirect)
    d. Vented heater required on ground slabs
4. Mud sill must not be placed on frozen ground (ACI 347 and OSHA)
5. Uneven settlement will occur

6. Where frozen only few inches
   a. Hot sand layer
   b. Steam heating
   c. Burning straw or hay (where environmentally OK)
   d. Covering with blankets for few days
   e. Be sure ground won't freeze during cure
7. Slabs 12 inches or less require blankets and heat; However, blankets can be used if left in place for a number of weeks

Concreting Above Ground in Cold Weather

1. Some advantage to richer mix design
   a. Reduce the amount of time for curing
   b. Concrete to produce high strength earlier
2. Enclosures must be used to maintain heat and moisture
3. Direct heater used for warming the underside
4. Preheat forms
5. Place blankets after finishing to maintain constant temperature and curing
6. Concrete should not be placed on frozen ground (chilling will cause weak concrete)

Enclosures

1. Wood, canvas, tarpaulins, polyethylene film, prefab, rigid-plastic
2. At least 6 feet above work area to protect from winds
3. Flying enclosures
4. Thermal blankets (dry)
5. 12-inch straw layer (dry)

Heaters

1. Indirect heater removes products of combustion
   a. Use where heat is applied to top of concrete
2. Direct heater
   a. Use where heat is applied under concrete deck, floor
3. Why?
   a. Fossil fuel produce CO_2 CO (Carbon Monoxide)
   b. Combines with calcium hydroxide
   c. This forms a weak layer of calcium carbonate
   d. This interferes with cement hydration (carbonation)
   e. Leave thin chalky layer of dust

4. Direct heating not to be used for at least 24 hours after pour
5. 600 PPM of CO can kill you in three hours
6. Salamanders are direct fired heater
7. Large electric blankets
8. Electric resistance wire placed in concrete
9. Form heaters

Duration of Heating

1. Until the concrete has reached a point of resistance to freeze and thaw cycle
2. Form stripping should be as specified in special provisions

Moist Curing

1. Strength gain stops when moisture for curing is no longer available
2. Concrete at 40°F to 50°F seldom loses enough moisture to impair curing
3. Live steam provides heat and moisture for extremely cold condition
4. Rapid drying when cold air is heated
5. Liquid membrane forming compounds used with direct or indirect heating (curing compound reduces carbonation)

Terminating the Heating Period

1. Rapid cooling should be avoided
   a. Can cause cracking
2. Reduce heat gradually
3. Discontinue moisture 24 hours before reducing heat

Form Removal

1. Leave forms on as long as possible
2. Use field test cylinders to determine strength of concrete required
3. If repair work is required, it should be accomplished now

Recap Ground Conditions

1. Do not pour concrete on frozen ground
2. Ground must be thawed out

Forms

1. Protected from cold weather
2. Insulated or heated
3. Re-steel and embedment thawed out
4. Thermal resistance electric wire placed

5. External heating
    a. Electric resistance wire
    b. Insulated blankets
    c. Burners and salamanders
6. Monitoring thermometers

Concrete Mixing

1. Warm aggregates, steam, or indirect heat
2. Use warm water (180°F maximum)
3. Mix warm water with aggregate before introducing cement
4. Transit mix dumps can be insulated for long hauls
5. Reduce standby time
6. Consolidate concrete ASAP

Placing Concrete

1. Loss of heat when using pumps, conveyors, pipes, and shutes
2. Form heating or insulation applied before placing
3. Prepare to handle problems
    a. Extra equipment
    b. Extra heating equipment
    c. Provide shelters (wind chill factor)

Finishing and Curing

1. Apply finish ASAP
2. Apply curing compound when required
3. Check form enclosure for draft or air leaks
4. Proper type of heating (direct or indirect)
5. Provide moisture during cure
6. Remove moisture 24 hours before reducing heat
7. Thermometers to monitor temperatures at corners and edges
8. Protect corners and edges from cold
9. Extra heaters and auxiliary power
10. Provide 24-hour watch for the first three days
11. Check heat during cold, windy days

Hot Weather Concreting

Hot weather concreting calls for special attention to controlling temperature of the concrete mix. Many methods can be used to cool aggregates, however; the contractor must provide evidence that it will not affect the quality of the product.

Water being the most controllable factor, it is the most economical to use. Therefore, a sufficient supply must be on hand at the plant and job site.

Transporting and placing must be limited to reducing the amount of time whenever possible.

Concreting in hot weather requires finishing and curing procedures to proceed without delay. Fog spraying and curing covers are essential to prevent reflective cracking.

Hot Weather Problems

1. Increased water demand
2. Slump loss earlier, and at a rapid rate
3. Increased rate of stiffness
4. Difficulties controlling air content
5. Plastic cracking
6. Prompts early curing

Water Added at Job Site

1. Decreases strength
2. Decreases durability
3. Nonuniform surface appearance
4. Tendency for shrinkage and thermal cracking

High Concrete Temperatures

1. Increases demand for water
2. Decrease the strength because of w/c ratio
3. Setting time reduced
4. Increases rate of hardening
5. High potential for shrinkage and plastic cracking
6. Requires added AE

Cooling Materials

1. Water is easiest to cool
2. Aggregates can be sprinkled
3. Aggregates shaded from the sun
4. Emersed in cool water tanks

5. Cold air circulation
6. Vacuum cooling
7. Don't bother trying to cool cement

Preparation Before Concreting

1. Shade equipment
2. Cover with wet burlap
3. Painted white (reflects the heat)
4. Wet subgrades
5. Fog spray forms and re-steel
6. Early morning or evening concrete placement

Transporting, Placing, Finishing

1. Delays cause slump loss and increased temperature
2. Adequate number of workman
3. Agitate mix intermittently
4. $1\frac{1}{2}$-hour limit from mixing to placing or 250 revs
5. Avoid cold joints (20 minutes between overlaps)
6. Floating and finishing after water sheen disappears

Plastic Cracking

1. Plastic cracks appear on horizontal surfaces
2. Produced by rapid evaporation
3. Plastic cracks caused when surface water evaporates faster than it can bleed from concrete naturally
4. Causes of plastic cracking:
   a. High concrete temperature
   b. Low humidity
   c. High winds
5. Plastic cracking unpredictable
   a. Sometimes at 0.2 lb./ft.^{2}/hr.
   b. Sometimes at 0.1 lb./ft.^{2}/hr.

Reducing the Problem of Plastic Cracking

1. Moisten subgrade and forms
2. Moisten aggregates that are dry and absorptive
3. Reduce wind velocity at work area directly over concrete surface

4. Erect temporary shade barriers
5. Keep fresh concrete temperature low by cooling aggregate and water
6. Protect the concrete with temporary coverings
    a. Polyethylene sheeting during delays
    b. Between placing and finishing
7. Reduce time between placing and curing
8. Apply moisture to finished surface by fog spraying
    a. Continue fog spray until liquid membrane-forming curing compound is applied
    b. Or wet burlap or curing paper or white plastic

Curing and Protecting

1. Retaining forms in position is not considered a satisfactory substitute for curing
2. Loosen forms and allow water to run over concrete
3. Curing water should be the same temperature as concrete or close to it
    a. Why? Causes differential stresses
4. First few hours is when curing is important
5. 24-hour moist curing critical
6. Moist curing should be continued throughout total length of cure during hot weather
7. Application of liquid membrane-forming compound during hot weather
    a. Preceded by 24-hour moist cure if possible
    b. Liquid membrane-forming compound applied after finishing if wet cure not possible

Admixtures

1. Air-entrainment
2. Water reducing additives

Heat of Hydration

1. Volume changes
2. Only considered in massive pours

Test Cylinders

1. Field test cylinder for form release are fabricated by the contractor as provided by WSDOT Test Method No. 809 5.(B) Handling and Storage of Cylinders
2. Test cylinders for acceptance of concrete shall be fabricated by the state using Test Method No. 809

Appendix C

Retaining Wall Standard Plan and Class Worksheet

DIMENSIONS (ft)				FOOTING REINFORCEMENT										STEM REINFORCEMENT									MATERIAL QUANTITY		
				BAR E		BAR F			BAR K					BAR M					BAR J			BAR G (size #4)			
H (ft)	B	C_v	D		h	SIZE	SPAC.	LENGTH	SIZE	SPAC.	LENGTH	h	b	SIZE	SPAC.	LENGTH	h	b	SIZE	SPAC.	LENGTH	LENGTH	CONCRETE CY/LF	STEEL LBS/LF	H (ft)
5	5'-6"	2'-0"	1'-0"	3'-4"	2'-9"	#4	9"	3'-6"	#5	9"	7'-2"	4'-7"	3'-0"									3'-10"	0.36	26.3	5
6	5'-6"	2'-0"	1'-0"	3'-4"	2'-9"	#4	9"	3'-5"	#5	9"	8'-3"	5'-7"	3'-1"									4'-10"	0.41	29.5	6
7	5'-9"	2'-3"	1'-0"	3'-4"	2'-9"	#4	9"	3'-4"	#5	9"	9'-7"	6'-7"	3'-5"									5'-10"	0.47	31.8	7
8	5'-9"	2'-3"	1'-0"	3'-4"	2'-9"	#4	9"	3'-3"	#5	9"	10'-8"	7'-7"	3'-6"									6'-10"	0.53	35.0	8
9	6'-0"	2'-3"	1'-0"	3'-4"	2'-9"	#4	9"	3'-1"	#5	9"	12'-0"	8'-7"	3'-8"									7'-10"	0.60	38.5	9
10	6'-3"	2'-3"	1'-0"	3'-4"	2'-9"	#4	9"	3'-6"	#5	9"	12'-11"	9'-7"	3'-9"									8'-10"	0.67	40.6	10
11	6'-6"	2'-3"	1'-0"	3'-4"	2'-9"	#4	9"	3'-8"	#5	9"	14'-0"	10'-7"	3'-10"									9'-10"	0.75	44.7	11
12	7'-0"	2'-6"	1'-0"	3'-4"	2'-9"	#4	9"	3'-10"	#5	8"	14'-4"	11'-7"	4'-2"									10'-10"	0.84	49.6	12
13	7'-6"	2'-6"	1'-0"	3'-4"	2'-9"	#5	10"	4'-7"	#5	7"	15'-5"	12'-7"	4'-3"									11'-10"	0.93	57.5	13
14	7'-9"	2'-6"	1'-0"	3'-4"	2'-9"	#5	9"	4'-8"	#5	7"	17'-7"	13'-7"	4'-4"									12'-10"	1.02	63.9	14
15	8'-3"	2'-6"	1'-0"	3'-4"	2'-9"	#5	7"	4'-10"	#5	6"	17'-9"	14'-7"	4'-6"									13'-10"	1.12	73.4	15
16	8'-9"	2'-9"	1'-3"	3'-8"	3'-0"	#6	10"	5'-6"	#5	6"	20'-1"	15'-7"	4'-10"									14'-7"	1.29	80.0	16
17	9'-3"	3'-0"	1'-6"	3'-8"	3'-0"	#6	10"	5'-8"	#5	6"	21'-5"	16'-7"	5'-2"									15'-7"	1.46	84.8	17
18	9'-9"	3'-3"	1'-6"	3'-11"	3'-3"	#6	9"	5'-10"	#6	7"	22'-7"	17'-7"	5'-5"									16'-4"	1.58	100.9	18
19	10'-0"	3'-6"	1'-9"	3'-11"	3'-3"	#6	9"	6'-3"	#6	6"	24'-0"	18'-7"	5'-10"									17'-4"	1.77	118.1	19
20	10'-9"	3'-6"	1'-9"	4'-2"	3'-6"	#6	8"	6'-5"	#6	6"	25'-2"	19'-7"	6'-0"									18'-1"	1.91	124.0	20
21	11'-3"	3'-9"	2'-0"	4'-5"	3'-9"	#6	8"	6'-10"	#7	1'-2"	17'-8"	11'-11"	6'-4"	#7	1'-2"	10'-7"	4'-10"	6'-4"	#7	1'-2"	18'-11"	18'-10"	2.12	133.8	21
22	11'-9"	4'-0"	2'-0"	4'-5"	3'-9"	#6	7"	7'-0"	#7	1'-1"	18'-5"	12'-4"	6'-8"	#7	1'-1"	10'-11"	4'-10"	6'-8"	#7	1'-1"	19'-11"	19'-10"	2.26	148.5	22
23	12'-3"	4'-3"	2'-3"	4'-8"	4'-0"	#6	7"	7'-2"	#7	1'-0"	19'-2"	12'-10"	7'-0"	#7	1'-0"	11'-6"	5'-1"	7'-0"	#7	1'-0"	20'-8"	20'-7"	2.49	161.3	23
24	12'-9"	4'-3"	2'-3"	4'-8"	4'-0"	#6	6"	7'-7"	#8	1'-2"	20'-7"	14'-2"	7'-1"	#8	1'-2"	12'-6"	6'-1"	7'-1"	#8	1'-0"	21'-8"	21'-7"	2.64	188.5	24
25	13'-3"	4'-6"	2'-6"	4'-11"	4'-3"	#6	6"	7'-9"	#8	1'-1"	21'-7"	14'-9"	7'-6"	#8	1'-1"	13'-2"	6'-4"	7'-6"	#8	1'-1"	22'-5"	22'-4"	2.89	205.0	25
26	13'-9"	4'-9"	2'-6"	4'-11"	4'-3"	#6	6"	7'-11"	#8	1'-0"	22'-2"	15'-1"	7'-11"	#8	1'-0"	13'-6"	6'-4"	7'-10"	#8	1'-0"	23'-5"	23'-4"	3.06	224.8	26
27	14'-3"	5'-0"	2'-9"	5'-2"	4'-6"	#6	6"	8'-1"	#9	1'-2"	24'-2"	16'-9"	8'-2"	#9	1'-2"	15'-0"	7'-8"	8'-2"	#9	1'-2"	24'-2"	24'-1"	3.33	253.9	27
28	14'-9"	5'-3"	3'-0"	5'-5"	4'-9"	#6	6"	8'-3"	#9	1'-1"	25'-0"	17'-3"	8'-6"	#9	1'-1"	15'-7"	7'-11"	8'-6"	#9	1'-1"	24'-11"	24'-10"	3.61	275.9	28
29	15'-3"	5'-6"	3'-3"	5'-8"	5'-0"	#6	6"	8'-5"	#9	1'-0"	25'-3"	17'-9"	8'-11"	#9	1'-0"	15'-7"	8'-2"	8'-11"	#9	1'-0"	25'-9"	25'-7"	3.90	299.0	29
30	16'-0"	5'-9"	3'-3"	5'-8"	5'-0"	#7	7"	9'-8"	#9	11"	26'-8"	18'-2"	9'-3"	#9	11"	16'-7"	8'-2"	9'-3"	#9	11"	26'-6"	26'-7"	4.12	340.3	30
31	16'-6"	6'-0"	3'-6"	5'-11"	5'-3"	#7	7"	9'-10"	#9	11"	27'-6"	18'-8"	9'-7"	#9	11"	17'-2"	8'-5"	9'-7"	#9	11"	27'-6"	27'-4"	4.43	352.3	31
32	17'-0"	6'-3"	3'-9"	6'-2"	5'-6"	#7	7"	10'-0"	#9	10"	28'-5"	19'-3"	9'-11"	#9	10"	17'-9"	8'-8"	9'-11"	#9	10"	28'-3"	28'-1"	4.76	390.0	32
33	17'-6"	6'-6"	4'-0"	6'-4"	5'-9"	#7	6"	10'-2"	#9	10"	29'-2"	19'-9"	10'-2"	#9	10"	18'-3"	8'-11"	10'-2"	#9	10"	29'-0"	28'-10"	5.09	406.4	33
34	18'-0"	6'-9"	4'-3"	6'-8"	6'-0"	#7	6"	10'-4"	#9	10"	30'-2"	20'-3"	10'-8"	#9	10"	19'-0"	9'-2"	10'-8"	#9	10"	29'-9"	29'-7"	5.44	417.8	34
35	18'-6"	7'-0"	4'-6"	6'-11"	6'-3"	#7	6"	10'-6"	#10	11"	32'-4"	22'-2"	11'-0"	#10	11"	20'-10"	10'-9"	11'-0"	#10	11"	30'-6"	30'-3"	5.79	491.0	35

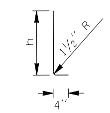
* If traffic barrier is used, add 0.100 CY of Concrete Class 4000 for Barrier Alternate 1. Add 0.123 CY of Concrete Class 4000 for Barrier Alternate 2 - L.F.

** Add 28 LBS of reinforcing steel for Barrier Alternate 1 or 19 LBS of reinforcing steel for Barrier Alternate 2 - per LF.

NOTES

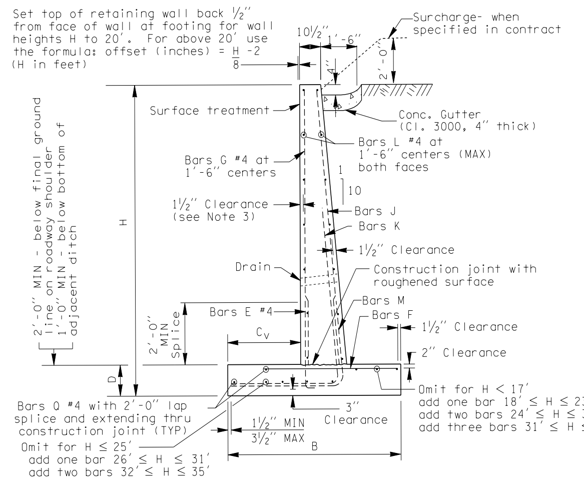
1. All concrete including traffic barrier shall be Class 4000 except as noted.
2. For backfill requirements, see Standard Plan "D-4".
3. When Wall Type 1-SW (saltwater) is specified, the concrete cover over steel in the front face and the total wall thickness shall be increased by 1".
4. When Wall Type 1-SW (saltwater) is specified, concrete in the table column "Material Quantity" shall be increased by 0.003 x H CY/LF.
5. If Bar W1 interferes with the retaining wall form, it shall be field bent only at the angle point. The bar shall not be twisted.
6. Toe height for traffic barrier may vary, 2" MIN to 6" MAX.
7. Height of traffic barrier may vary if required to provide a profile pleasing to the eye.
8. Concrete in the 24 foot wall sections shall be placed separately between expansion joints with a minimum 12 hour period between concrete placement.

Bar	MIN Splice
#4	2'-0"
#5	2'-0"
#6	2'-1"
#7	2'-11"
#8	3'-9"
#9	4'-9"
#10	6'-1"

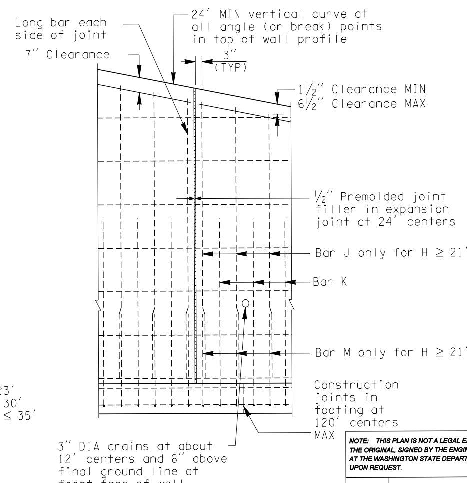


BAR E

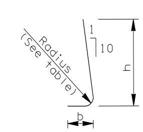
At 1'-6" centers



SECTION - VERTICAL FACE



ELEVATION



Bar	Radius
#5	9"
#6	11"
#7	1'-1"
#8	1'-3"
#9	1'-6"
#10	1'-8"

BARS K AND M

WALL DESIGN WITH VERTICAL FRONT FACE AND 2' SURCHARGE OR TRAFFIC BARRIER

EXPIRES JUNE 29, 2002

REINFORCED CONCRETE RETAINING WALL TYPE 1 AND 1 SW STANDARD PLAN D-1a

SHEET 1 OF 2 SHEETS

APPROVED FOR PUBLICATION

Harold J. Peterfeso 01-23-02

STATE DESIGN ENGINEER DATE

Washington State Department of Transportation

NOTE: THIS PLAN IS NOT A LEGAL ENGINEERING DOCUMENT BUT AN ELECTRONIC DUPLICATE. THE ORIGINAL, SIGNED BY THE ENGINEER AND APPROVED FOR PUBLICATION, IS KEPT ON FILE AT THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION. A COPY MAY BE OBTAINED UPON REQUEST.

DATE	REVISION	BY
8/01	corrected concrete quantity for barrier alternate 2	MAS

Washington State Department of Transportation

Field Note Record (Sketch Grid)

Book No. ________ Page No. ________

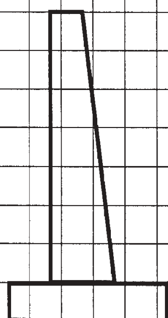
Contract No.	Station	Line	C/S
5180	50+50 to05073	LE	051800

Staked By	Date	Work Started	Work Completed
The B Crew	May 18, 2000		

Calculated By	Date	Checked By	Date	Inspector's Signature	Date
The Class					

H = 12' Length = 23'

B = D =



Notes;

Clearance from top of footing to first "L" bar is 2".

Clearance from end of wall at each end for the "L" bar is 11/2".

Concrete Quantity =

Bar	Spacing	Size	lb/ft	Length	Quantity	Weight
E						
K						
L						

Item No.	Item	Group No.	Date	Unit	Quantity	RAMS No.	Basis of Material Acceptance	CAPS Entry No.	Initials Post	Initials OK	Est. No.
45	Steel Rein. For Ret. Wall	2		lb.							
46	Conc. Cl. 4000 For Ret. Wall	2		cy							

DOT Form 422-636 EF
Revised 9/96